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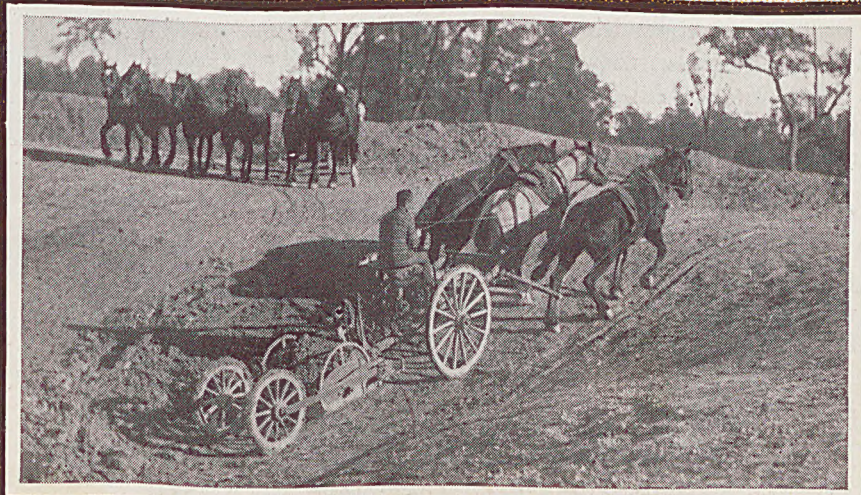
The JOURNAL OF THE DEPARTMENT of AGRICULTURE

VICTORIA — AUSTRALIA

NATIONAL MUSEUM OF VICTORIA

VOL. XXXII PART 8



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Issued under the direction of the Hon. J. Allan, M.L.A., Minister of Agriculture.

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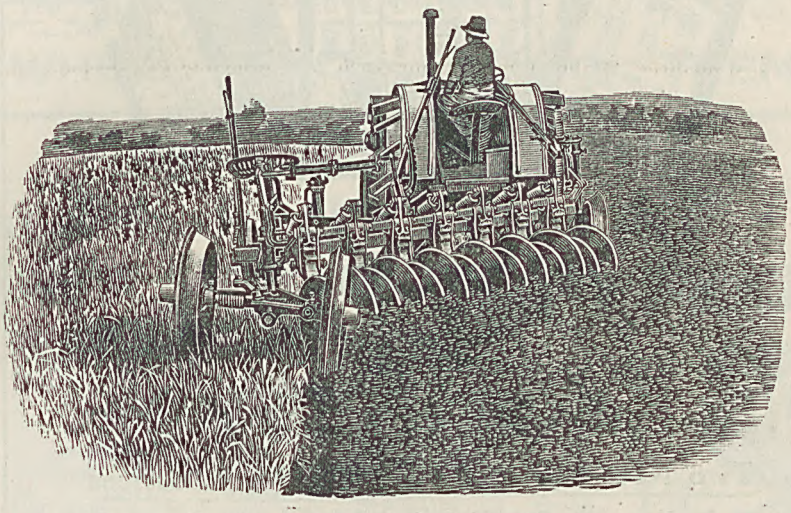

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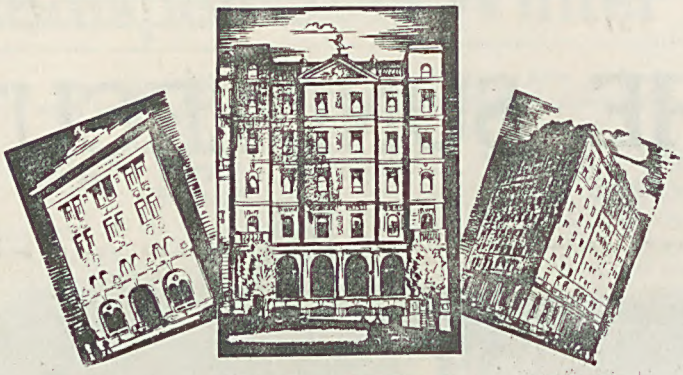

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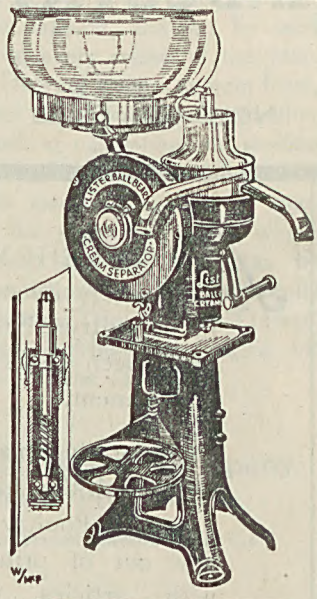

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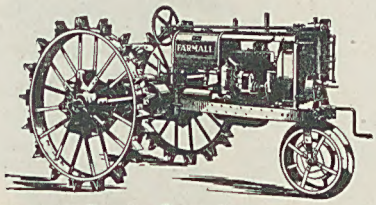

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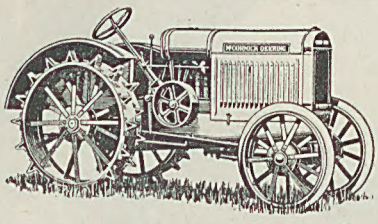

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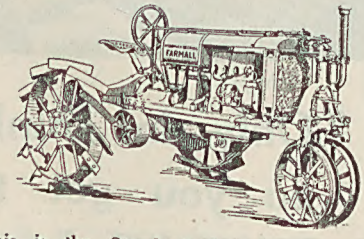

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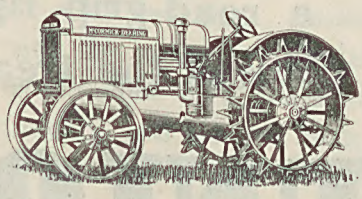

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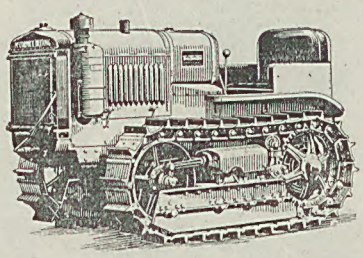

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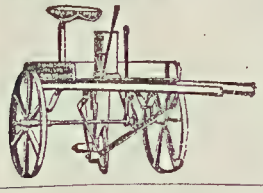

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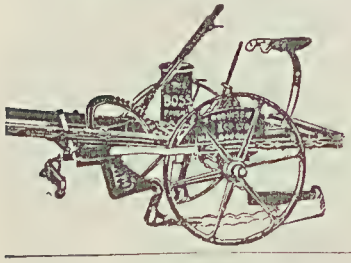

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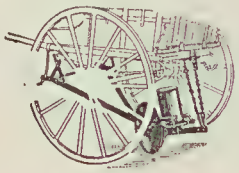

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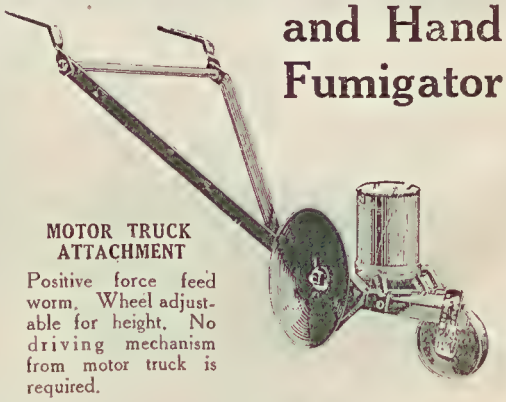

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The Journal of the DEPARTMENT of AGRICULTURE of VICTORIA

Tar Distillate Sprays

Uses on Fruit Trees

By Keighley M. Ward, M.Agr.Sc., Assistant Entomologist.

DURING the past four years considerable interest has been displayed by Victorian fruit-growers in a new spray material known as tar distillate emulsion. The use of this material on deciduous fruit trees, particularly on peach and nectarine trees, against the green peach aphid (*Myzus persicae* Sulz.), has increased fairly rapidly in Victoria and other parts of Australia, but there is a scarcity of information regarding the spray available to fruit-growers. It seems desirable, therefore, that a general account of the material should be given.

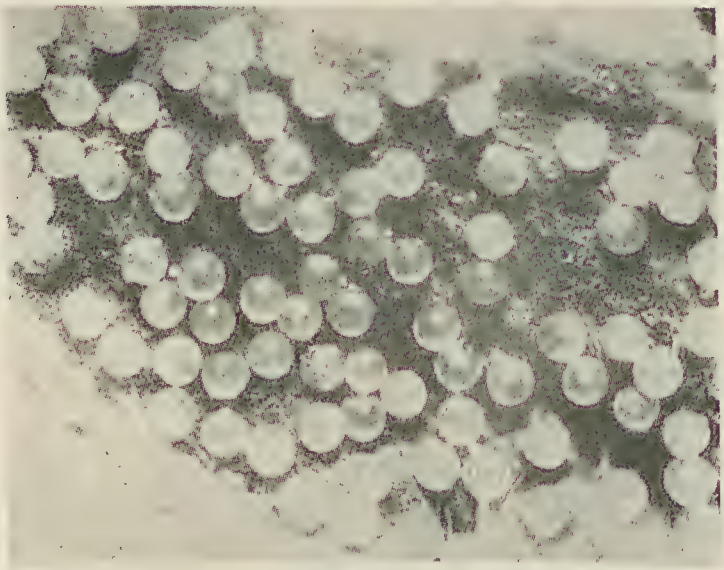
Tar distillate, or tar oil, used in spray fluids belongs to the aromatic series of organic compounds and is a distillation product of crude tar, which is obtained as a by-product in the manufacture of commercial coal gas. Tar-oil sprays differ from lubricating-oil sprays in that the latter are derived from petroleum or mineral oils (aliphatic oils).

Development as an Insecticide.

Various forms of tar-oil emulsions have been in use as insecticides against fruit tree pests for many years, particularly in European countries. In Germany the insecticidal value of "carbolineum" was recognized as early as 1908. This material had as a basis certain products obtained from the distillation of coal tar, and was used largely to immunize timber against insect attack, and later was painted or sprayed on fruit trees. Although it was no doubt improved in the course of years in Germany, Holland, and Russia, apparently it was prepared without a full knowledge of its insecticidal action, or of the constituents responsible for the destruction of insects. It appears to have been used chiefly as a contact insecticide against mature insects, its egg-killing properties not being realized.

Modern tar distillate sprays have originated from this rather crude material. In 1921 a tar-oil wash was introduced into England from Holland, and investigations were commenced at Long Ashton Research Station, Bristol. The results of this and other work which has extended over a number of years have been published from time to time, a detailed account being given by Staniland, Tutin, and Walton (1) in 1930. The investigation showed that a spray consisting of certain fractions of material distilled from coal tar would be of great value against certain pests of deciduous fruit trees. Moreover, the work indicated that tar distillate would prove of greatest value when used against the over-wintering stages of insects, e.g., eggs. Indeed, it is now recognized that this material possesses a degree of insecticidal efficiency against certain pests which is not equalled by any other known spray material, and as a result of its use a number of important fruit tree insects have been brought under control.

Tar-oil sprays have been the subject of investigations in the United States of America for about six years, and valuable information has been gained (see Hartzell and Parrott, 1933 (2), Hough, 1932 (3), and others). The material has been tested against numerous fruit tree insects with satisfactory results, and it seems likely that it will be used there fairly extensively in the future. It is also being tested in South Africa (Andries,



Eggs of the Red Spider. These are not destroyed by tar distillate so readily as the eggs of aphides. Improved tar oil washes may be found for this purpose. (Enlarged.)

1932) (4), New Zealand (Cunningham and Muggeridge, 1933), and Australia (Hely, 1933, Ward, 1934).

The use of the material has been confined to deciduous fruit trees which were quite dormant, and when applied to trees just emerging from this state, or to trees bearing foliage, severe injury has resulted. It seems possible, however, that *foliage sprays* may be developed from the material when more exact knowledge concerning its insecticidal action is available. With this knowledge it should be possible to use more highly refined material from which injurious constituents have been removed. Trials in the use of tar distillates on trees in foliage have been carried out already in New York State. Ordinary tar distillate was applied in summer at a dilution of 0·75 per cent., and in combination with lime-sulphur and Bordeaux mixture. Although the materials were compatible when in combination sprays, the tar distillate was responsible for injury to the foliage and fruit even at the weak concentration used.

Efforts are being made to extend the range of usefulness of tar oils by incorporating petroleum oil in tar distillate emulsions. By this method it is hoped to be able to obtain complete control of a number of insects, including San José scale and apple capsid bugs, which were only partially controlled by straight tar distillate. In general, however, this work is still in the experimental stage.

Composition and Preparation.

When coal is subjected to distillation processes at increasingly high temperatures numerous substances are obtained. According to Cunningham and Muggeridge (5) the order in which the various groups of compounds appear is :—

1. Benzines — at temperatures ranging from 40° to 150° C.
2. Phenols—boiling point 150° to 210° C.; used for disinfectants, insecticides, &c. Carbolic acid and naphthalene are products of this group.
3. Creosote oils—boiling point 210° to 270° C.; used as wood preservatives and insecticides.
4. Anthracene oils (green oils)—boiling point 270° to 400° C.; used as wood preservatives and insecticides.
5. Pitch—comprises residue.

Older " carbolineum " washes consisted for the most part of creosote, with a proportion of phenols. The tar distillate introduced into England in 1921 was found to have a boiling point range of 190° to 360° C., and thus contained materials in groups 2, 3, and 4. The distillate contained 10 to 20 per cent. of " tar acids " (cresols and phenols), and was emulsified by means of resin soap.

In the subsequent work at Long Ashton the distillate was divided into various components in order to determine where the egg-killing properties lay. The " tar acids " were separated from the neutral material, and each portion was further divided. The neutral material was separated into two parts, one with a boiling point range of 190° to 280° C., and the other with a range of 280° to 360° C. As these two portions cooled down after distillation solid naphthalene was deposited from the first and anthracene from the second. These solid substances were discarded. The two neutral portions were referred to as " low neutrals " and " high neutrals."

With regard to the " tar acids " two fractions were used in the tests, one boiling at 190° to 220° C. (the " low phenols "), and the other at 280° to 360° C. (the " high phenols "). These four fractions were emulsified and tested against eggs of a moth and an apple aphid, the " neutrals " being tested alone and combined with 20 per cent. of " tar acids." The conclusions reached as a result of these tests were, firstly, that the

portion of the distillate boiling above 280° C. was the more toxic to both moth and aphid eggs; and, secondly, that the inclusion of phenols or tar acids lowered the toxicity of the material. It was thus evident that the most efficient tar distillate washes should consist of oils contained in the anthracene group (group 4).

Hartzell and Parrott (2) in New York State have confirmed the Long Ashton assertion that "tar acids" are undesirable in tar distillate emulsions, but they indicate that emulsions containing the fractions with boiling points ranging from 280° to 360° C. are not necessarily the only valuable fractions. Materials distilling at temperatures above 200° C., and therefore including creosote oils, were also very effective. They found that the fraction obtained at 200° to 270° C. was very toxic to the eggs of the green apple aphid (*Aphis pomi* De G.). Their work thus suggests that tar distillate having a wider boiling point range than 280° to 360° C. will be very useful, but it is necessary to refine the material, the removal of "tar acids" in particular being desirable.

The preparation of stable emulsions of tar distillate was included in the Long Ashton investigations. It was found that the neutral material could not be satisfactorily emulsified with the castor oil and resin soaps which were used successfully in distillates containing "tar acids." The neutrals were satisfactorily emulsified by means of a sulphonated oil, Agral W.B. This oil was mixed with the neutrals in the proportion of 1 in 9, and the mixture placed in a spray pump and the requisite amount of water added. The emulsification was completed by adding caustic soda solution at the rate of 2 oz. per gallon of the mixed neutrals and Agral. In the United States satisfactory spray fluids have been prepared from local crude tar oils by using sulphonated cod oil and caustic soda.

Several writers, notably Tutin, also Hartzell and Parrott, have suggested the home preparation of tar distillate sprays by fruit-growers. The success of this practice depends largely upon the orchardist being able to procure the proper fraction of tar distillate and also a suitable sulphonated oil as an emulsifying agent. It should not be very difficult to obtain the necessary materials, but it is doubtful whether a suitable home-made tar-oil spray could be prepared in Victoria at a cost much below the market price of the commercial product.

Insects Controlled by Tar Distillate.

As has already been stated, tar distillate washes are employed principally on dormant fruit trees against the winter eggs of insect pests. In England notable success has been achieved in the control of several major pests of apples, pears, and plums. Among these the apple capsid (*Plesiocoris rugicollis* Fall) and the green capsid (*Lygus pabulinus*) were formerly controlled with difficulty, but are now completely checked by means of tar oil washes. These insects deposit winter eggs under the bark of apple twigs in such a way that only a very small portion of each egg was exposed. Tar distillate is apparently able to destroy these eggs when it comes into contact with the small exposed portions. Other English pests controlled by means of these sprays are aphides of apples, pears, plums (*Aphis pomi* De G., *Anuraphis roseus* Baker, &c.), winter moths (*Cheimatobia brumata* L., &c.), apple sucker (*Psylla mali* Schmidb.), and gooseberry red spider (*Bryobia ribis* Thom.).

Eggs of the Red Spider.

In the United States successful control has been obtained of apple aphides, oystershell scale (*Lepidosaphes ulmi* L.), black cherry aphid (*Myzus cerasi* L.), pear psylla (*Psylla pyricola* Forst.). Inconclusive results were obtained when used

Eggs of Green Peach Aphid at side of bud on peach lateral.

against other insects, including capsid bugs and San José scale.

Experimental work on the use of tar distillate sprays has been carried out in two States in Australia, viz., New South Wales and Victoria. Investigations were initiated in 1929 in the Murrumbidgee Irrigation Area of N.S.W., while the Victorian work was commenced a year later. In both cases the object of the investigations was to find an improved method of controlling the green peach aphid (*Myzus persicae* Sulz.), the principal insect pest of the peach in both States. Laboratory tests have shown that the winter eggs of the insect are destroyed more readily by tar distillate than by other types of ovicide, while field trials have proved that the insect can be effectively controlled by means of a dormant-period application of the spray. Reports on the work have already appeared (Hely, 1933 (6), Ward, 1934 (7)). This work has now passed a little beyond the experimental stage, and tar distillate washes are being used in increasing quantities in the peach-producing areas of both States.

In Victoria the use of tar distillate against other insects attacking fruit trees has not been investigated as fully as its use against the green peach aphid. Field tests of a preliminary nature are being made against the black cherry aphid, San José scale, and Bryobia mite. Results obtained from these tests do not permit of conclusions being drawn as yet.

Effects on Fruit Tress.

Commercial tar distillates now in use are essentially dormant-period sprays, and will cause injury to leaf and fruit buds if applied to trees not completely dormant. Even weak dilutions of the sprays apparently cannot be used on foliage without causing injury. Six or seven varieties of peach trees at the Burnley Horticultural Gardens have received applications of the material at a strength of 3 per cent. in four successive years without showing signs of injury. On the contrary, peach trees sprayed with the material seemed in general to be more healthy than unsprayed trees, while their foliage was of a deeper green colour, was more profuse, and the leaves were somewhat larger. In other parts of the State tar distillate has been applied to dormant plum, cherry, and pear trees without producing harmful effects.

In England, where the washes are used at strengths of from 6 per cent. to 12 per cent., damage has been caused to the buds of several kinds of fruit, in many cases the growth of fruit and leaf buds having been completely inhibited or destroyed outright. Another effect of the sprays was to retard blossoming. This retardation of flowering has been noticed also in America on apple, pear, and cherry trees, but the effect of this action was not considered to be serious. In Victoria this effect has not been noticeable on peach trees.

Directions for using Tar Distillate.

The use of tar distillate sprays in Victoria has been fairly fully investigated only with regard to the green peach aphid. Therefore the following directions apply to their use against this insect only.

Time of Application.—Since the winter eggs of the aphid commence to hatch early in July, it is advisable to apply the material between the last week in June (by which time egg-laying is usually completed) and the second week in July. Whenever possible, calm days should be selected for the spraying, and the material should not be applied when the trees are wet, during a frost, nor when the temperature is below about 45° F. It is not necessary to delay spraying until after the trees are pruned, since unpruned trees do not require more spray material than pruned.

Strength of Mixture.—The rate at which tar distillate should be used is 3 gallons of concentrate in 100 gallons of spray mixture, or according to the directions given with each of the several brands on the market. In experimental work in the Goulburn Valley strengths of 1 in 40 (2.5 per cent.) and 1 in 70 have given fairly effective control of the aphid. Where a mixture weaker

than 3 per cent. is used the quantity of spray mixture applied to each tree should be increased.

Method of Spraying.—Since the eggs of the aphid are very small and are deposited close in to the side of the buds and in small cracks in the bark, it is very important that trees be sprayed thoroughly if satisfactory control is to be obtained. Special attention should be given to laterals at the tops of the branches since these are the most easily missed. Every part of the tree must be wetted.

In view of the burning effect which tar distillate has on the skin, spraying should be carried on in such a way that the operator is able to avoid spray drift. This can best be achieved by spraying *with the wind* as much as possible, and not against it.

When stock tar distillate emulsion has been standing for a considerable time it may separate out into various layers, therefore, before using the material it should be thoroughly mixed in the container, e.g., by rolling backwards and forwards.

Protection of Operator.—The spray operator should take precautions to prevent himself from becoming severely burned while applying tar distillate. In the first place he should keep out of the spray drift as much as possible. Secondly the face should be protected by means of a suitable mask with goggles for the eyes, or by means of some protective substance smeared liberally on exposed skin. So far the most suitable material found here for this purpose is castor oil. Petroleum grease, such as vaseline, has been found ineffective in many cases, especially when spraying in sunshine. According to Hartzell and Parrott the burning of the skin may often be reduced by washing with vinegar, diluted at the rate of one part to three parts of water. Finally, the operator is reminded that the horses drawing the spray pump will probably be susceptible to the burning by the spray, and they should be protected by waterproof covers.

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Fertilizers Registered—Supplementary List

SUPPLEMENTARY LIST OF FERTILIZERS REGISTERED AT THE OFFICE OF THE DIRECTOR OF AGRICULTURE UNDER THE FERTILIZERS ACT 1928 (No. 3680) FOR THE YEAR 1934.

Description of Fertilizer.	Brand.	Nitrogen.		Phosphoric Acid.			Price asked per ton.	Where Obtainable.
		As Bone and Blood.	Total.	As Citrate Soluble.	As Citrate Insoluble.	Total.		
		%	%	%	%	%	£ s. d.	
Blood and Bone ..	Cockatoo ..	4·56	4·56	5·90	5·88	11·78	6 0 0	Richard Fordham, Cressy-road, Camperdown
Animal Fertilizer ..	Pannifex No. 6 ..	6·00	6·00	6·00	10·00	16·00	7 10 0	H. C. Pannifex and Co., 149 Stanley-street, West Melbourne
" " ..	" No. 7 ..	4·00	4·00	7·00	9·00	16·00	6 15 0	" " "
" " ..	" No. 8 ..	4·75	4·75	6·50	12·50	19·00	7 10 0	" " "

Description of Fertilizer.	Brand.	Nitrogen.	Phosphoric Acid.	Mechanical Condition.		Price asked per ton.	Where Obtainable.
				Fine.	Coarse.		
		%	%	%	%	£ s. d.	
Bonedust ..	Apex ..	3·90	24·30	50	50	7 10 0	North-Eastern Bone Products, Bowser
" ..	B	3·35	23·20	60	40	7 0 0	Thomas Benson, Woodford

W. R. JEWELL,
Chemist for Agriculture.

Melbourne, 20th July, 1934.

Twinning in Cattle

By A. C. T. Hewitt, M. Agr. Sc.,
State Research Farm, Werribee

Netherlana—mother of three sets of twins.

THE occurrence of twins in cattle breeding is fairly common, but only rarely do cows give birth to triplets and quadruplets, though cases are on record where triplets and quadruplets have been born and reared (1). The apparent rarity of multiple births in cattle is largely due to the fact that breeders have bred sparingly from twins and have encouraged the factors for desirable beef and dairy qualities rather than those bringing about multiple births. In contrast, multiple births are definitely encouraged among British breeds of sheep, while with pigs it is an essential character for a sow to bear large and strong litters. Among horses, however, multiple births are even more rare than among cattle, and they are discouraged.

From the careful studies which have been made of twinning in human beings it would appear that the tendency to twinning is inherited. Little information is, however, available with regard to the inheritance of twinning in cattle. The present investigation has been undertaken with the object of ascertaining the extent and mode of inheritance of twinning in cattle, and of studying certain related aspects of the subject, such as the occurrence of freemartins and of like-sexed twins, the relative birth weights of twins and single calves, the influence of the season of the year on twinning, mortality among twins and the relation of twinning to the age and period of gestation of the dam.

Source of Data.

Data have been secured from the breeding records kept by the Victorian Department of Agriculture. Records relating to the Victoria stud of Red Poll cattle are available for the past 24 years, while those relating to the stud of Friesian cattle extend back for fifteen years.

The Incidence of Twins.

In the Red Poll stud 1,260 births have been recorded, and of these 26 have been twins, equal to one twin birth in every 48 births. Two hundred Friesian births have been recorded, and of these six have been twins, equal to one twin birth in every 33 births. The occurrence of twins has been considerably above the figure (1 in 80) quoted by Hammond (2) as being the normal proportion. This high proportion is probably due to the presence of twinning strains (see p. 389). There have been no triple or quadruple births recorded in either of these studs.

The Sex Ratios.

Of the 26 pairs of Red Poll twins, four were twin bulls, fifteen were bull and heifer twins, and seven were twin heifers; and of the six Friesian twins, two were twin bulls, three were bull and heifer twins, and the remaining pair were twin heifers. These are tabulated in Table I.

Table I.—The Sex Ratios.

	Sexes of Twins.		
	Bulls.	Bull and Heifer.	Heifers.
Red Poll	4	15	7
Friesian	2	3	1
Total ..	6	18	8

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The preponderance of odd-sexed twins in these records supports the view that identical twins (i.e., those arising from a split ovum) are relatively infrequent in cattle.

The Freemartin.

From Table I. it will be observed that there have been fifteen Red Poll and three Friesian freemartins. Twelve of the Red Poll freemartins have been reared to maturity, and all were found to be barren. Only one of the Friesian freemartins was reared to maturity, and she proved fertile and was the heaviest producer of milk and butter-fat in the herd. Her average mature equivalent of production is 18,380 lb. milk, 3.44 test, and 632 lb. butter-fat.

With one exception all the twin bulls that have been reared have been used or sold as stud bulls. The one exception—a Red Poll—was not visibly entire. One twin Red Poll bull and three twin Friesian bulls have been successfully used as stud bulls in the herds under investigation.

The freemartins at birth appear to be normal heifers, but by examining the udders and teats of the freemartin at three or four months old it can usually be ascertained which freemartins will be breeders and which will be barren. The udder and teats of the barren freemartin make practically no development after birth, conspicuous by the teats remaining the same size and the absence of "leather" in the udder. As the barren freemartin becomes older the non-development of the udder and teats becomes more and more conspicuous; she does not reach puberty at the normal age of five to nine months, as shown by the absence of the three-weekly oestral periods; and she becomes more and more like the steer in her general conformation and absence of sexual impulses.

Birth Weight of Twins.

The birth weights of only four pairs of twins—all Red Polls—have been recorded, and they are shown in Table II. Victoria Cutty Spark's twins were premature and hence they were small, otherwise the twin calves were all strong normal calves and were only slightly below the average weight of single calves. The average birth weights of Red Poll and Friesian single calves are tabulated in Table III.

A typical freemartin—Victoria Cuticle (2-yrs.-old).

Table II.—The Birth Weights of Twin Calves.

Dam.	Larger Twin.		Smaller Twin.	
	Sex.	Weight. lb.	Sex.	Weight. lb.
Cutty	Heifer	66	Heifer	60
Victoria Royal Blue ..	,,	70	,,	58
Victoria Cutty Spark	Bull	54	,,	43
Victoria Cutty Sulu ..	,,	73	,,	60

Table III.—Average Birth Weights of Single Calves.

Sex of Calves.	Red Poll.		Friesian.	
	Number.	Weight. lb.	Number.	Weight. lb.
Bull ..	123	77·7±0·9	29	91·7±1·6
Heifer ..	118	72·0±0·9	30	85·5±1·6

Udder and teats of 18 months old heifers—left, normal heifer; right, freemartin.

It will be observed from Table III. that bull calves are from 5 to 6 lb. heavier at birth than are heifer calves, and that Friesian calves are approximately 14 lb. heavier than Red Poll calves.

Like-sexed Twins.

Very little data on the like-sexed twins are available, but all the like-sexed twins have been as easily distinguishable from one another as ordinary herd members. The birth weights of two pairs of like-sexed twins are shown in Table II., and although Cutty's twins only differed by 6 lb. in birth weight they differed greatly in general conformation. Victoria Royal Blue's twins were also very dissimilar.

Victoria Freemartin Mature Equivalent Production—18,380 lb. milk, 3.44 per cent. test, 632 lb. butter-fat.

In only one instance are the standard milk and butter-fat records (as obtained under the conditions at Werribee) of twin heifers available, and their average mature equivalents of production are shown below:

Gelderlana A: 10,757 lb. milk, 3.88 test, 413 lb. butter-fat.

Gelderlana B: 8,872 lb. milk, 4.42 test, 384 lb. butter-fat.

Gelderlana A was a high producer of milk and butter-fat with a low test, while Gelderlana B was an average producer of milk and butter-fat with an average test.

From the general external characters and the few characters that have been measured, it appears that all the like-sexed twins born in the Departmental herds have been fraternal and not identical twins.

The Mortality Among Twins.

The percentage of twin calves reared does not differ greatly from that of single calves, as shown by the figures in Table IV.

Table IV.—The Percentage of Calves Reared.

—	Percentage Reared.
Total Red Poll calves	81·2
Red Poll twin calves	75·0
Total Friesian calves	79·0
Friesian twin calves	83·0

Cutty—Mother of three sets of twins.

These figures exclude abortions, and all calves that have died or been destroyed on account of being undersized or delicate. Over the whole period losses from abortion alone have been slightly over 9 per cent. of all calves born. During the past five years, however, the losses from this cause have been reduced to 6 per cent. Only two pairs of twins—both Red Polls—have been aborted, and this is just over 6 per cent. of all twins dropped. A much larger percentage might have been expected on the assumption that a twin pregnancy is a greater drain on the resources of the dam, but this evidently does not reduce the resistance of a cow against abortion.

Twinning Strains.

In the Red Poll herd two families have borne half the Red Poll twins. They are the Connecticut and Virginia families. In the Connecticut family, Cutty has had twins thrice, Victoria Cutty Sulu, a daughter of Cutty, has had twins four times, and Victoria Cutty Spark, a granddaughter of Cutty, has had twins twice, although only once in the Departmental herd. The occurrence of twins in these two families is shown in the following genealogical trees. The number in brackets following the name represents the number of twins each cow has had. The names underlined are the cows, while the names not underlined are the sires.

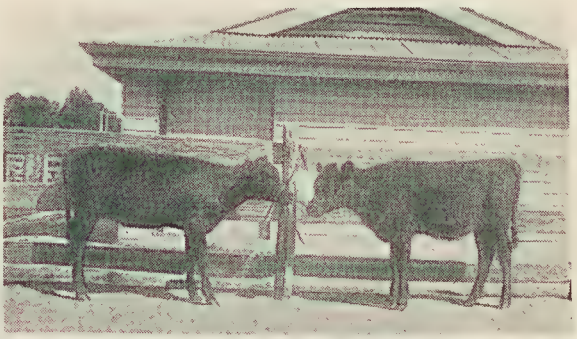
Gestation Period of Twin Pregnancies.

In Table V. are shown the average gestation periods for male, female, and twin pregnancies for both Red Poll and Friesian breeds.

Table V.—Gestation Periods for Red Poll and Friesian Cows Carrying Male, Female and Twin Foetuses.

Foetus Carried by Cow.	Red Poll.		Friesian.	
	Number of Pregnancies.	Gestation Period (days).	Number of Pregnancies.	Gestation Period (days).
Male ..	412	285·9±0·5	58	282·9±0·9
Female ..	376	285·0±0·5	65	282·5±0·6
Twin ..	22	277·4±2·4	3	272·7±5·0

A group of twins at Werribee.



Twin heifers—apparently not identical.

It will be noticed that the gestation period for twins is eight days shorter in the case of the Red Poll, and ten days shorter in the case of the Friesian, than for single pregnancies. The average gestation period for Friesian cows is approximately three days less than for Red Poll cows. The average gestation period for a cow bearing a bull calf is less than one day longer than that for a cow bearing a heifer calf. It is commonly believed that a cow that "goes over her time" will drop a bull calf, but the differences in the gestation periods shown in Table V. are not sufficient to support this belief.

The disparity between the totals given in Table V., and the total births given on p. 386, is accounted for by many of the births following on paddock matings, the actual dates of which are not known.

The Age of the Dam.

There appears to be no definite age at which a cow is most likely to drop twins. Results tabulated in Table VI. show that the percentage of twins increases with the age of the cow. In this table the age of the cow is expressed in number of calvings. No heifers have dropped twins at their first calving, a small percentage of cows have dropped twins at their second calving and this percentage has increased irregularly at each successive calving. Many of the longest lived cows have had twins on one or more occasions, and it appears that some of the characters contributing to the character for twinning also contribute to the characters for long life and fertility. Long life and fertility cannot very well be separated when discussing dairy cattle because, immediately a cow becomes infertile or barren, she is marketed for slaughter.

The three longest lived Red Poll cows have been Virginia, Cutty, and Nictitana. Virginia at nineteen years old and at her fifteenth calving gave birth to twins; she was marketed for beef

twelve months later. Cutty and Nictitana remained fertile and productive to the ages of seventeen years, and both had had fourteen calvings and were the dams of twins. Cutty bore twins on three occasions, at seven, fourteen, and fifteen years old, while Nictitana bore twins once at seven years old.

The Effect of Season of the Year on Twinning.

Twin calves have been dropped during all seasons of the year in fairly equal proportions, as shown in Table VII., indicating that the season of the year has no influence on twinning.

Victoria Ilka Tinkle at 18 months old—Mature Equivalent Production: 13,117 lb. milk; 3·45 per cent. test; 453 lb. butter-fat.

Table VI.—The Number of Single and Twin Calvings of Cows at Different Ages (Expressed in Calvings) and the Percentage of Twins Dropped.

Age of Cow (Calving).	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.	13th.	14th.	15th.
Red Poll—															
Total calvings ..	400	261	180	130	92	70	47	31	19	12	6	4	4	3	1
Twin calvings ..	0	3	5	3	0	3	2	1	1	1	0	1	1	0	1
Percentage of twins..	0·0	1·2	2·8	2·3	4·3	4·3	4·2	3·2	5·3	8·3	0·0	25·0	25·0	0·0	100·0
Friesian—															
Total calvings ..	56	38	31	23	20	14	8	5	2	2	1	..	..	..	..
Twin calvings ..	0	2	1	0	0	0	3	0	0	0	0	..	..	..	..
Percentage of twins..	0·0	5·3	3·2	0·0	0·0	0·0	37·5	0·0	0·0	0·0	0·0	..	..	..	..
Total percentage of twins—both herds ..	0·0	1·7	2·9	1·9	3·6	3·6	9·1	2·8	4·8	7·1	0·0	25·0	25·0	0·0	100·0

Table VII.—Total Calves and Twin Calves Dropped During the Different Seasons of the Year.

Season.	Spring.	Summer.	Autumn.	Winter
Red Poll—				
Total calvings ..	371	344	251	338
Twin calvings ..	6	7	6	7
Friesian—				
Total calvings ..	84	35	30	51
Twin calvings ..	1	3	0	2

Twins and Milk and Butter-fat Production.

The average mature equivalent of milk and butter-fat production in 273 days of the twins, the dams of twins, and all other cows, tested in both herds under the conditions governing the Standard Herd Test of Victoria, have been worked out and are tabulated in Table VIII. All the records are corrected for age, to make them comparable. Correction factors worked out by the writer (3) have been used to correct the Red Poll cow's records, and correction factors worked out by Gowen (4) have been used to correct the Friesian cows' records.

Table VIII.—The Average Mature Equivalent Milk and Butter-fat Records of Twins, Dams of Twins, and All other Cows in the Red Poll and Friesian Herds, Indicating a Possible Correlation of Twinning Tendency and High Production.

—	Number.	Milk.	Butter-fat.	Butter-fat
		lb.	%	lb.
Red Poll cows—				
Twins	4	9,623	4·46	418
Dams of twins ..	18	9,407	4·44	408
All others ..	233	8,398	4·37	359
Whole herd ..	255	8,488	4·38	363
Friesian cows—				
Twins	2	15,750	3·45	547
Dams of twins ..	5	12,636	3·58	452
All others ..	44	10,825	3·59	414
Whole herd ..	51	11,196	3·58	423

[*Continued on page* 402.

Pollination Problems.

By A. G. Strickland, M.Agr.Sc.,

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FRUIT-SETTING, or the process by which blossom is converted into fruit, is very complex, and when fruit trees bloom profusely, and yet fail to set a crop, this failure may be due to a diversity of causes. It may be the result of bad weather during blooming, or of the depredations of some disease or insect pest; it may be due to faulty drainage, manuring, or cultivation; but very often another factor is responsible, and that is lack of pollination.

Our forefathers planted orchards of mixed varieties, and the presence of bees and other insects permitted the wholesale exchange of pollen between different varieties. This pollen exchange is termed cross-pollination, and although those planters of mixed orchards did not fully realize it, such cross-pollination is absolutely necessary for the production of satisfactory crops of fruit.

The growth of the fruit industry resulted in the partial abandonment of this very excellent practice of jumbling varieties in an orchard. Orchardists began to specialize in the growing of selected varieties, and in many instances established large blocks of a single variety, which were denied the necessary cross-pollination. In the case of most fruits, reduction, or almost total failure of crops, was the result of this practice.

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It was thus that the pollination problem arose, not only in Australia, but throughout the whole world; and although due regard is usually paid to the matter of pollination when establishing new orchards, there are still many patches of trees in this State which have little or no pollination facilities.

When bad weather prevails during blooming, or when other disturbing factors occur, such as the thrips' infestation of 1931, the beneficial effects of adequate cross-pollination are more obvious, and, conversely, the disastrous effects of inadequate pollination are also obvious. After a season or so of adverse conditions, there is generally more than ordinary interest in pollination problems, and the provision of better facilities in this respect. In seasons when weather is favorable for fruit-setting, the advantage of effective cross-pollination is not so marked, and after a few such seasons many growers forget all about it, and the advantages it gave in the bad years.

The last two seasons in Victoria have provided good conditions for fruit-setting, and the keen interest in pollination displayed after the disastrous spring of 1931 has waned considerably. Pollination, however, is so important that no grower can afford to lose interest in it.

There are two rather distinct phases of the problem for the orchardist. One is concerned with the relative ability of varieties to set fruit with or without cross-pollination, the varieties which need pollinating most, and the best pollenizers to use. The other phase is the distribution of pollen in the orchard, and involves a consideration of how bees and other insects effect this distribution, and how varieties should be mingled in the orchard in order to enable the pollen to be distributed to the maximum advantage.

The ability of different varieties to set fruit with their own pollen varies considerably. At one extreme we find that peaches and apricots are nearly all capable of setting a maximum crop without any cross-pollination. For obvious reasons they are termed self-fruitful. Therefore, either peach or apricot trees may be planted in solid blocks of one variety without fear of any reduction in yield. Most varieties of other deciduous fruits do not show this capacity of cropping fully without cross-pollination; they are termed self-unfruitful.

The degree to which such fruits are self-unfruitful differs from variety to variety, and some of the cherries and plums are completely unable to set fruit with their own pollen.

The majority of apple, pear, cherry-plum, and almond varieties are self-unfruitful to varying degrees, and cannot be expected to crop to their utmost unless they are provided with pollinizing varieties. Most apple and pear trees are not so markedly dependent on cross-pollination as are some cherries and plums, and will often yield reasonable crops in favorable seasons without the aid of cross-pollination. On this evidence, the grower often assumes that they do not require cross-pollination, and when in seasons of an unfavorable nature these same varieties exhibit a partial failure, he apportions all blame to the effects of the season. Actually, the lack of cross-pollination is usually the cause. Naturally, the weather is such in some seasons that cropping must suffer, even under the best conditions of pollination; but, generally speaking, the better the pollination facilities, the more capable are trees of setting fruit under adverse circumstances. Most of us can recall striking instances of this fact, which occurred during the thrips' invasion of 1931.

As cross-pollination is essential to ensure regular and maximum cropping, orchards should comprise a suitable admixture of varieties, so that the pollen of one variety may be conveyed to the blossoms of another, and ensure the setting of fruits. The very first necessity is that the varieties intended to pollinate each other should blossom at the same time. Jonathan and Rome Beauty apple trees, for instance, are not fitted to pollinate each other, as the former has usually almost finished blooming by the time the flowers of Rome Beauty commence to open.

The fact that two varieties of a particular fruit bloom at the same time does not necessarily imply that they are suitable pollinizers for each other. Some varieties of apples and other fruits produce non-viable pollen; or, in other words, pollen which cannot fertilize a bloom owing to its inability to germinate. Varieties yielding this sort of pollen are practically useless from a pollination stand-point.

A further complexity which limits our choice of suitable varieties for cross-pollination is the inability of some varieties to pollinate other varieties. This disability exists

Bees in the Orchard.

between some cherry and plum varieties; an extreme illustration of the phenomenon is the unsuitability of Japanese and European plums for pollenizing each other. This type of disability does not occur between apple or pear varieties, and is most commonly encountered in the case of certain pairs of cherry varieties.

As a class, apples and pears are seldom completely self-unfruitful, but are generally partially so, and will set their fruit far more consistently when two or more varieties are interplanted. Lack of adequate pollination is very often evidenced by a heavy drop of young fruits. Whenever this happens, it will pay growers to cut a number of the fallen fruits open and observe their seed content. If they contain an average of five or more seeds each, it is probable that lack of pollination is not the cause of the dropping; probably it is nutritional, or in some way due to weather conditions. But if, on the other hand, fallen fruits contain few or no seeds, it may be taken as an indication that lack of proper pollination has caused this loss of fruit; and, furthermore, that the provision of pollinating varieties would probably result in better cropping. With the exception of varieties which produce weak, non-viable pollen—such as Gravenstein and Reinette du Canada—any apple may be used to pollinate any other apple; and similarly with pears, always provided that the pollinating varieties bloom at the same time as the varieties to be pollinated.

As a general rule, cherry, plum, and almond varieties exhibit self-unfruitfulness more completely than do apples or pears. Some few plums and cherries are fairly productive without cross-pollination, but all sweet cherries and many Japanese and European plums will not crop to capacity unless they are cross-pollinated. Some of them will fail completely unless they receive the pollen of other varieties. Occasional incompatibility between varieties occurs with these fruits, and more care in selecting pollenizers is necessary than is the case with apples and pears.

Apple Trees in Full Bloom.

A considerable amount of data regarding blooming dates and the value of different varieties from a pollinating stand-point has been obtained, and the Department of Agriculture will gladly assist growers to select suitable pollenizers for their orchards.

The second phase of the pollination problem concerns pollen distribution. What is the best method of mingling pollenizing varieties? How is the pollen to be distributed from tree to tree throughout the orchard so that interplanted varieties may exchange pollen? The pollen of all the fruits under consideration is adapted to distribution by insects, and wind or other agencies of dispersal are quite unimportant. In Victorian orchards, the domesticated honey-bee is the main agent of pollen-transfer, and cross-pollination cannot proceed unless there are sufficient bees among the fruit trees during blooming. In districts where bee-keeping is general there are plenty of bees if weather conditions are favorable, and where an orchardist has no hives he can rely on his neighbour's bees acting as pollen distributors. But in orchards where bees are lacking, it is essential for the grower to see that some are introduced; one hive for every 1 or 2 acres of mature orchard is a reasonable provision.

In the mingling of varieties in an orchard, it is a fundamental necessity that no tree should be more than two trees distant from another pollenizing variety. This requirement is satisfied by alternating double rows of each of two varieties, and where two good commercial varieties are being planted, this is probably the best method of distributing them. If even numbers of the two varieties are not required, and mixed rows are not objectionable, the planting of a pollenizing variety as every third tree in every third row will be a suitable arrangement.

Re-working of some trees to another variety is the approved method of rectifying lack of pollination in an established orchard; usually the third tree in every third row is re-worked. In other cases, one or two limbs of every tree in the patch are grafted over to a suitable pollenizer, and this method is particularly effective; especially when bad weather is experienced during blooming.

As a consequence of the restriction of apple export to certain specified varieties, it is probable that many apple trees will be re-worked during the next few years. This re-working should not be rushed blindly, as it may well provide an opportunity for improving the pollination facilities in many orchards. The disposition of varieties from a pollination stand-point should be studied, and the re-working so arranged that every tree will get the maximum cross-pollination that is feasible.

Progress Report on Pollination Experiments

DURING the first year, these experiments were confined chiefly to a broad survey of the problems in regard to apples. In subsequent seasons, the work was extended to embrace pears and cherries; and, although in many instances there has been insufficient seasonal replication to arrive at definite conclusions, it is thought that, at this juncture, comment may be made on certain phases.

Throughout the investigations, self-fruitfulness and cross-fruitfulness have been determined by means of the "branch unit" method described by MacDaniels (1). Uniform branches were selected on one or more trees of the variety under investigation, and a preliminary count of fruit buds made on each branch. Some of these branches were left without protection from insects as checks, and others were enclosed in cheese-cloth bags 6 feet long and 3 feet wide, just before the opening of the blossoms.

When the blossoms were at the correct stage, bags were removed in order to apply pollen of the desired varieties to the respective blooms. After such application, the bags were replaced. Owing to the failure of all blooms on the one branch to attain receptivity simultaneously, this application of pollen had to be repeated two or three times in most instances.

The various pollens were collected previously and applied by means of a camel hair brush; in the case of selfing, mere brushing of the blooms with a camel hair brush was found to be quite effective in transferring pollen from stamens to stigma.

Pollen has been collected by gathering half-opened blooms of the desired varieties, combing the unripe anthers into petri dishes, and ripening these anthers under suitable conditions. Maintaining a sufficient supply of pollen has been the greatest difficulty in this work, and this difficulty has greatly limited the scope of the investigations.

Counts of fruit have been obtained at two periods, in December after the first drop, and in February or March just prior to harvesting. At harvest, representative fruit samples have been examined in order to arrive at a reliable estimate of seed content.

During the first two seasons, laboratory determinations of pollen viability were made, but the pressure of field work precluded these determinations during the season 1933–34.

Fruit setting has been expressed as a percentage of the total blooms setting fruit, and also as a percentage of flower clusters setting fruit.

1.—*Experiments with Apples.*

(*a*) *Self-fruitfulness.*—All of the apple varieties under investigation have demonstrated self-unfruitfulness, i.e., inability to set satisfactory crops with self-pollination. The degree of such self-unfruitfulness has differed somewhat from variety to variety, but in each of the three seasons under review, it has been sufficiently marked to indicate a definite necessity for cross-pollination of all varieties.

There is also a marked variation in the degree of self-fruitfulness of individual varieties in different seasons. In certain favorable seasons, apple varieties generally tend to produce more fruit from self-pollination than in less favorable seasons, and the consideration of one season's results might quite easily lead to a wrong estimate of the capacity to crop without cross-pollination.

The following varieties have shown varying degrees of self-unfruitfulness:—Jonathan, Stewarts, Granny Smith, Rome Beauty, London Pippin, Gravenstein, Alfriston, Cleopatra, Delicious, Sturmer, Tasma, Pomme de Neige, Lord Nelson, Lord Wolseley, Dunns, Statesman, Shoreland Queen, Reinette du Canada, Cox's Orange Pippin, Twenty Ounce, and Rymer. The last-named variety has shown a tendency to set rather more freely with self-pollination than do other varieties, but still benefits greatly from cross-pollination.

(*b*) *Cross Fruitfulness.*—No evidence of cross unfruitfulness has been encountered in any of the variety combinations used in crossing experiments. Crossing experiments with the object of comparing the value of different pollenizers for the chief apple varieties have been conducted for a single season only, and require confirmation in succeeding seasons. The available evidence indicates that Jonathan is adequately pollinated by Granny Smith, Yates, Statesman, or Stewart's. In practice, however, the latter variety would tend to be an undesirable pollinator, owing to its marked alternate year bearing habit. London Pippin and Rome Beauty satisfactorily pollinate each other, but here again alternate bearing may constitute a practical difficulty. Stewart's is satisfactorily pollinated by Jonathan and Granny Smith, Granny Smith by Jonathan and Stewart's, and Statesman by Stewart's and Jonathan.

Extension of these experiments to include other varieties has been planned, and over a series of seasons it should be possible to determine the best pollinators for each of the chief apple varieties.

(*c*) *Seed Content.*—These experiments have demonstrated the value of the seed content of mature fruits as an indication of the relative effectiveness of the pollenizer. The number of seeds varies with the variety, and although the average seed content of cross-pollinated fruits is usually in the region of six to eight with most apple varieties, Stewart's was outstanding with an average seed content of over twelve seeds per fruit as a result of pollination with Jonathan or Granny Smith. The lowest seed content occurs with self-pollination; and averages varying from one to four are the rule with self-pollinated fruits of various varieties. There are indications that different pollinating varieties give varying average seed contents in the resultant fruit from one variety, and other writers have pointed out that this denotes a difference in effectiveness of the pollenizer.

It is certain that the figure for average seed content, when used in conjunction with setting percentages, is a valuable aid in evaluating different pollenizing varieties. By the same token, a critical examination of the seed content of a number of fruits will aid the orchardist in determining whether or not certain varieties are adequately pollinated.

(*d*) *Viability of Pollen.*—During the two seasons 1931 and 1932, pollen of a number of apple varieties was germinated on a medium containing 10 per cent. cane sugar and 1½ per cent. agar.

The percentage of viable pollen found for each variety in 1931 and 1932 is shown in Table I., and in each case the figure is based on counts of some hundreds of pollen grains.

It will be noted that the results are in accord generally with those recorded by other investigators (Reinecke, Kvaale, Kobel, and Florin).

The triploid varieties Gravenstein, Reinette du Canada, and Rhode Island Greening produce pollen of extremely low viability, and for this reason, cannot be recommended as pollenizers.

TABLE I.

Variety.	Percentage of Viable Pollen.	
	1931.	1932.
Alfriston	42	90
Cleopatra	28	86
Cox's Orange Pippin	..	93
Crofton	..	96
Delicious	35	92
Dougherty	..	90
Duke of Clarence	..	83
Dumelow	..	88
Dunns	..	73
Emperor Alexander	..	91
Esopus Spitzenberg	..	86
Granny Smith	43	92
Gravenstein (x)	Nil	1
Jonathan	..	92
Lalla	..	97
London Pippin	..	99
Lord Nelson	..	80
Lord Suffield	..	98
Lord Wolseley	47	97
Newman's Sdg.	..	92
Nickajack	31	98
Northern Spy	..	98
Pomme de Neige	..	92
Prince Alfred	..	55
Reinette du Canada (x)	0·0	0·7
Rhode Island Greening (x)	2	Nil
Rokewood	..	90
Rome Beauty	26	90
Rymer	..	96
Statesman	..	72
Stayman	..	16
Stewart's	38	94
Stone Pippin	..	65
Sturmer Pippin	26	88
Tasma	..	89
Twenty Ounce	..	82
Yates	..	72

A noteworthy feature of the figures in Table I. is the consistently lower pollen germinative capacity in 1931 of varieties which showed normal pollen viability of 70 to 90 per cent. in 1932. This abnormally low pollen viability occurred during the disastrous Spring which was the occasion of a general failure of the Victorian apple crop. The severe thrips infestation which was experienced in the Spring of 1931, was probably a major factor in causing the reduction of crops, but many facts point to the contributory effect of quite different factors. Read (2) has suggested that the prolonged growth period, which was a feature of the growing season previous to the Spring of 1931, had an adverse effect on fruit bud initiation, both in respect to the number of buds formed, and in respect to the strength of buds which were initiated. The general low level of pollen viability in 1931 may quite conceivably be regarded as an index of the general debilitation of the 1931 bloom, and consequent reduction of its ability to set fruit. It is not suggested that low pollen germination was a direct cause of poor setting, as even despite a lower percentage of viable pollen, there should remain sufficient good grains to ensure fertilization. The low pollen germination, however, draws attention to the possibility of "internal" tree factors as distinct from the "external" thrips factor, contributing somewhat to the general crop failure. Quite apart from considerations of thrips damage, apple varieties were self-unfruitful to a greater degree in 1931 than in subsequent seasons, and accordingly showed more benefit from cross pollination.

II.—Experiments with Pears.

(*a*) *Self-fruitfulness of Varieties.*—The degree of self-fruitfulness of the chief pear varieties has been investigated by means of the branch unit method for two seasons. All varieties showed self-unfruitfulness to a degree, although there was a general tendency to set more fruit with self-pollination in 1932 than in 1933. This was due to a seasonal capacity of some varieties to produce seedless fruits in 1932. Although the degree of self-fruitfulness was lower in 1933, the average number of seed per fruit in the case of selfed branches was higher than in 1932.

The following varieties have shown partial self-unfruitfulness during the two seasons under review:—Beurre Bosc, Beurre' d'Anjou, Howell, Packham's, Winter Cole, Josephine, Keiffer's, Williams Bon Chretien, Winter Nelis, and Doyenne du Comice.

In 1932 Howell, Packham's, and Winter Cole generally exhibited a higher degree of self-fruitfulness than other varieties. This was due largely to a greater capacity of setting seedless fruits in this particular season. In the subsequent year, a study of average seed contents showed that this capacity of the three varieties was not so marked, and as a result they were no more self-fruitful in 1933 than were other varieties.

Although we find varying degrees of self-fruitfulness among pears generally, any such capacity depends largely on variety, season, and locality, and is of low order in most cases.

In the Doncaster experiments all varieties showed more or less improvement in cropping as a result of cross-pollination.

(*b*) *Cross Fruitfulness.*—The experiments in regard to the relative effectiveness of different pollenizers for each of the chief pear varieties have been in progress for one year only. In this one year, slight differences in the effectiveness of various pollenizers have been noted, but it would be impossible to specify the superiority of any particular pollinating varieties without seasonal replication of the work.

No cases of cross-unfruitfulness between any of the various combinations of pear varieties have occurred, although as stated previously, slight differences in the effectiveness of certain pollinators were evident.

III.—Experiments with Cherries.

These experiments have been conducted for one season only, and naturally no conclusions may be drawn from them until they have been repeated over several seasons.

As in the case of other fruits, the branch unit method has been used, and altogether ten of the chief cherry varieties were dealt with in 1933. From one point of view, it would have been preferable to investigate fewer varieties, and so enable the use of a greater range of pollinating varieties and better replication of treatment. It was considered, however, that in the first year at least, the pollination status of as many important varieties as possible should be broadly investigated. Such a broad investigation enables a clearer understanding of the general problem, and facilitates the planning of more detailed experiments on those varieties most needy of investigation. The main difficulty in all pollination work is the immense amount of routine which must be carried out in the comparatively short period during which the trees are in bloom, and the ground that may be covered by a single investigator is necessarily limited.

As was the experience with apples and pears, the collection of sufficient pollen for the purpose of field cross-pollination greatly limited the amount of work that could be carried out.

At the outset, two trees of each of the following cherry varieties were selected in convenient orchards in the Blackburn district:—Burgsdorf Seedling, Early Purple Guigne, Black Bigarreau, Chapman, Bedford, Bigarreau Twyford, Bigarreau Napoleon, Reine Hortense, Florence, and Margaret. The selected trees were healthy and vigorous, and four uniform branches were selected and labelled on each of the two trees of each variety. Of the eight limbs selected for each variety, two were bagged and self-fertilized, two were left open to orchard pollination, and four were bagged and crossed with two different pollinating varieties. Counts of the number of fruit buds, fruit bud clusters, and estimates of the total number of blossoms were made for each limb prior to bagging.

Of the ten varieties under investigation, Bigarreau Napoleon was the only one that showed any tendency to set fruit from self-pollination (3.1 per cent. of blossoms set fruit); all other varieties were for all practical purposes completely self-unfruitful.

In the case of every variety except Burgsdorf Seedling, bagged limbs which were artifically cross-pollinated, showed a very much lower set than limbs which were open pollinated. This may have been partly due to damaging of blooms whilst applying pollen, but in all probability was mainly due to an insufficient supply of pollen. Under the circumstances, it was impossible to maintain an adequate pollen supply for crossing purposes.

General indications from this preliminary work suggest that Burgsdorf, Early Purple Guigne, and Black Bigarreau satisfactorily pollinate each other. Twyford and Bedford suggest themselves as satisfactory pollenizers for Florence, and for each other. Pending further experiments, Margaret does not appear to be a suitable pollenizer for Reine Hortense, although it gave a moderate set when used on Bigarreau Napoleon; Reine Hortense also gave preliminary evidence of its probable suitability as a pollenizer for Bigarreau Napoleon.

It must be fully understood that these suggestions in regard to the relative value of the several varieties for interpollination are only tentative, and whilst suggestive of the lines of future investigations, need to be checked over several seasons.

Owing to the lower sets experienced on bagged limbs which were artifically cross-pollinated, as compared with the sets obtained under open pollinated conditions, the results of the crossing tests are not so conclusive as could be desired. Nevertheless, the set under bagged conditions was uniformly lower throughout all varieties, and with all pollenizers, and the figures obtained therefore have some comparative value.

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Bee-keeping for Beginners

Part III.—Manipulation

By J. W. Thomlinson, Apiary Inspector.

[Previous articles of this series appeared in the February and June issues of this Journal.]

SUCCESS in the manipulation of the interior fittings of a hive and the removal of surplus honey is dependent to a great extent on the confidence of the individual. Most people are naturally nervous when first making direct contact with a colony of bees, but a little practice will soon convince the beginner that, provided reasonable precautions are taken, bees may be handled quite safely, and with the risk of very little more than an occasional sting.

Colonies vary considerably in temperament. To examine some, the bee-keeper will at times require no protection against stings, but will find it impossible to handle others without the subduing effect of smoke, and the protection of a veil. It is therefore necessary, with the object of guarding against the possibility of an unpleasant experience, to afford protection for the face, arms, and ankles, and to have a well-lighted smoker available before opening a hive.

The type of smoker recommended is that shown in Fig. 1. One may be obtained in which there is a barrel made of either brass or tin, and although it will cost a little more one with a brass barrel will probably prove more economical owing to its lasting qualities. For general use the $3\frac{1}{2}$-in. size is likely to be the most suitable.

Various materials may be used as fuel for the smoker. Some prefer bark, others wood shavings, or cotton waste, but in the opinion of the writer there is nothing better for producing a good even smoke than a strip of jute torn from a discarded wheat sack. Material from a sack that has been out in the weather, and which consequently may

Fig. 1.—Contents of tool box:—1. Smoker; 2. Reserve smoker-fuel; 3. Claw hammer; 4. Pliers; 5. Hive tool; 6. Painter's scrape; 7. Screw driver; 8. Damp cloth; 9. Tins for nails.

be easily torn, will be found to ignite more readily than a strip from a comparatively new one.

The best way to prepare jute for smoker fuel is to cut or tear it into strips of not more than 6 inches wide; these should be made into rolls slightly less than the diameter of the smoker barrel; a piece of string tied around the centre of each will keep it compact and ready for use.

When about to use the smoker, dip one end of the fuel roll in water, remove quickly and wring out; the damp end will act as a spark arrester, ensure a cool dense smoke, and also prevent the fuel from burning too quickly. The other end must be lighted and placed in the smoker barrel, and the hinged nozzle closed, when a few puffs from the bellows should give the required smoke. To make sure that there will be no difficulty in keeping the roll alight, a few live coals from the kitchen fire may be placed in the smoker barrel before the fuel is inserted. On no account should an attempt be made to use the smoker until it is well alight and a steady stream of smoke available, as air or dust from the smoker when directed at the bees will cause irritation instead of subjection.

For the protection of the face a veil is necessary. This should be made of black mosquito netting, black being necessary for clear vision; it should be of such dimensions that when in use it will be well away from the face and the back of the neck. Small veils are often responsible for quite a lot of unnecessary stinging. A veil when finished should be about 30 inches square. One side should be hemmed to take a piece of elastic, which should be drawn tightly enough to fit snugly around the crown of the hat.

To arrange the veil, first remove the coat and vest; then place the elastic band around the crown of the hat and allow the veil to fall over the head and shoulders; replace the vest; and pull the material well clear of the face and back of the neck, and if desired replace the coat.

The arms may be protected by placing rubber bands over the coat sleeves at the wrist, but a much better way is to use gauntlets made from cotton material hemmed at each end and elastic inserted so that the gauntlets will fit neatly at the wrist and just below the elbow. This will give ample protection and prevent bees from getting under the sleeve of coat or shirt.

It is advisable to wear boots in preference to shoes when handling bees. Rubber bands, or leather cycling gaiters may be used to keep the bottom of the trousers tight against the boots. If shoes be worn, leather cycling gaiters are necessary, otherwise the ankles may receive quite a lot of attention from angry bees.

Fig. 2.—Discarded six inch super. converted into a combined seat and tool box.

Rough woollen garments should be avoided, as nothing is more likely to cause bees to sting than their coming in contact with the rough surface of coarse woollen material. The operator wearing shoes should, therefore, be careful not to wear worsted socks.

It is quite possible to open the hive and examine the interior with no further aid than that rendered by the veil and smoker, but when a number of hives has to be overhauled, the work will be done more quickly and thoroughly with the help of a small kit of tools.

A box should be provided to hold the required tools, and each article must be replaced immediately after using; this may save quite a lot of annoyance caused through the loss of implements, which if put on the ground, frequently get covered with grass, dust, or dried leaves, and may not be missed until again required.

A portable seat will obviate the necessity of kneeling on damp ground while combs are being examined in search of the queen; or if the operator be stooping over the hive for any length of time the use of a seat will relieve the strain on the muscles of the back and enable the work to be done without unnecessary fatigue.

Seats are generally dispensed with in the apiary owing to their bulkiness and the time occupied in shifting them, but as shown in Fig. 2, a discarded 6-in. depth super. can easily be converted into a convenient, light, and portable combined seat and tool-box, capable of holding the smoker when not in use, the necessary tools, nails, and reserve smoker-fuel. This can be done by nailing two 6-in. pieces of light wood, such as may be obtained from a petrol case, on the side of the super.

In Fig. 1 the contents of the tool-box are shown:—(1) smoker; (2) reserve smoker-fuel; (3) claw-hammer for effecting repairs to frames and hives; (4) pliers for removing nails that

Fig. 3.—Opening the hive; directing smoke at entrance.

cannot be drawn with the claw-hammer; (5) hive-tool for separating frames and supers; (6) painter's scraper for quickly removing burr-comb from frames and sides of hives, and also propolis, a resinous substance gathered by the bees and used by them for sealing undesirable spaces; (7) 12-in. screw-driver, which some prefer to the hive-tool for separating frames and retrieving pieces of burr-comb from between frames; (8) a damp cloth for removing honey from the hands; and (9) tins containing an assortment of nails.

A small bucket of water should also be on hand for rinsing tools that come in contact with honey. The hands should be kept as free from water as possible; immersing them in water softens the skin and thus, in the event of a person being stung, permits of a deeper and more rapid penetration than is the case where the skin is harder. For this reason, when one is engaged at the hives a damp cloth only should be used for the removal of honey from the hands.

It must be remembered that no matter how carefully a hive is opened a certain amount of disorganization of the colony with consequent loss of time will take place. Therefore, the use of the smoker should be restricted to the minimum necessary for the reasonable subjection of the members, and as soon as the work undertaken is finished, the hive should be closed again as quickly as possible.

The quantity of smoke necessary to subdue bees depends, to a certain extent, on the temperament of the members in each particular colony. The peculiarities of each hive will soon be learned by experience. Weather conditions and food supplies have also to be taken into consideration. Bees are usually more irritable during close thundery weather, and when there is a scarcity of honey, than at other times, consequently more smoke would be required under those conditions than during normal periods.

Opening the Hive.

To open the hive, first make sure that the smoker is well alight, walk to the side of the hive from which it is intended to work, place the nozzle of the smoker near the entrance, press the bellows four or five times, directing the smoke well into the entrance (Fig. 3). After the space of half a minute repeat the operation, using about half the quantity of smoke, then raise the corner of the lid, lift the mat and direct a similar quantity of smoke along the top of the frames (Fig. 4). The lid and mat should then be removed.

It should be distinctly understood that the above direction regarding the quantity of smoke to be used would apply to an average colony, some may require more, others less; the operator would have to use his own discretion as to the amount required.

Fig. 4.—Opening the hive; directing smoke between frames.

After the lid and mat have been removed, direct a little smoke across the frames, but not directly into the hive unless this be found necessary; place the smoker on the ground within easy reach, then with the hive-tool or screw-driver loosen the frames and remove one (the second from the far side is usually the most convenient), examine the comb on both sides, then carefully place the bottom of the frame on the ground and lean the top against the side or back of the hive—on the shady side during warm weather (Fig. 5).

With one frame out of the hive, no difficulty will be experienced in separating the remainder, and concluding the examination. If the bees become troublesome, a little more smoke should

Fig. 5.—The hive opened.

be gently directed over the frames; then proceed quietly and avoid all quick movements. As each comb is examined it should be replaced in the hive; care is essential to see that bees are not crushed between the closed portion of the end bars of the frames. The examination completed, press the frames together, leaving a space for the one first removed; this frame should now be lifted with the palms of the hands against the end bars and the thumbs locked over the projecting ends of the top bar (Fig. 6). While held in this position, if the weather be warm, the bees should be dislodged in front of the hive by sharply jolting the frame downwards (Fig. 7). After being dislodged the bees will find their way into the hive through the entrance; the frame should then be replaced and the hive closed. Should the weather

Fig. 6.—To dislodge bees from the comb; note position of the hands.

be at all cold, or evening be approaching, and the young ones in danger of becoming chilled before finding the entrance to the hive, the bees should be dislodged on top of the frames and driven below with a few light puffs from the smoker.

Fig. 7.—Bees dislodged from the brood comb.

The Sting.

To the naked eye a bee sting is merely a small dark-brown object with a ball of greyish matter attached to the base, but a microscope will show that it is composed of three parts, two of which are barbed and joined to the third by means of partly closed grooves. At the base of the sting, with an outlet along a groove, is a small sac containing a clear liquid. Should the sting be driven into a substance capable of engaging the barbs and offering resistance to its withdrawal by the controlling muscles, the bee becomes a prisoner, securely held by its own sting. Immediately the insect realizes this its whole strength is brought into action in a frantic effort to get free, with the result that the sting and surrounding muscles, and sometimes other organs, are torn from the body, and left behind, an injury which must ultimately prove fatal to the bee.

On being stung by a bee one feels a sharp burning sensation and at once the small ball of greyish matter attached to the affected spot can be seen. On no account should an attempt be made to remove the sting by taking the visible matter between the thumb and forefinger; it should be removed immediately by being scraped away with the finger nail. The grey matter will be composed of muscles, still actively working, and the sac containing liquid which, when injected into the puncture made by the sting, is responsible for the pain.

Unless stung on such sensitive places as the tip of the nose or lobe of the ear, the severity of a sting is governed by the amount of liquid injected into the puncture; so it should be quite obvious that any movement to remove the visible matter except by scraping the injured part, will have the effect of compressing the sac and forcing the liquid along the groove of the sting into the puncture.

In the event of a severe case of stinging and subsequent swelling, the application of hot foments will afford relief. To relieve the effect of a casual sting, except for the application of heat, very little can be done in the way of applying remedies, owing to the smallness of the puncture made by the sting; though tincture of iodine, if applied immediately, may afford a certain amount of comfort.

Twinning in Cattle (*Continued from page* 390).

It is interesting to note that the twins and the dams of twins have been consistently heavier producers of milk und butter-fat than have been the ordinary herd members, and it appears that there may be a close association between the genetic characters for multiple births and those for high milk and butter-fat production. Possibly some of the factors contributing to the character for high milk and butter-fat production also contribute to the character for multiple births.

Summary.

1. The incidence of twins has been one twin birth in every 48 Red Poll births, and one twin birth in every 33 Friesian births.

2. So far as is known no identical twins have been dropped.

3. Thirteen of the fourteen freemartins reared have been barren.

4. The birth weight of twin calves has been only slightly lower than that of single calves. Bull calves have been approximately 6 lb. heavier than heifer calves.

5. The mortality amongst twins is approximately equal to that amongst single calves.

6. Twinning appears to be inheritable and to run in strains.

7. The gestation period of a cow bearing twins has been from eight to ten days shorter than that of a cow bearing a single calf.

8. The percentage of twins dropped increased as the age of the dam at calving increases.

9. Twinning is not influenced by the season of the year.

10. The twins and dams of twins have been consistently heavier producers of milk and butter-fat than the other herd members.

11. There is some evidence to suggest a close genetic relationship between the following three characters: (i) multiple births, (ii) high milk and butter-fat production, (iii) long life and fertility.

Acknowledgments.

The writer gratefully acknowledges assistance given by the late Dr. S. S. Cameron, formerly Director of Agriculture of Victoria, and Prof. W. E. Agar, Professor of Zoology, University of Melbourne. Dr. Cameron was responsible for the founding of these studs, and he inaugurated and maintained the system of recording that has made this study possible.

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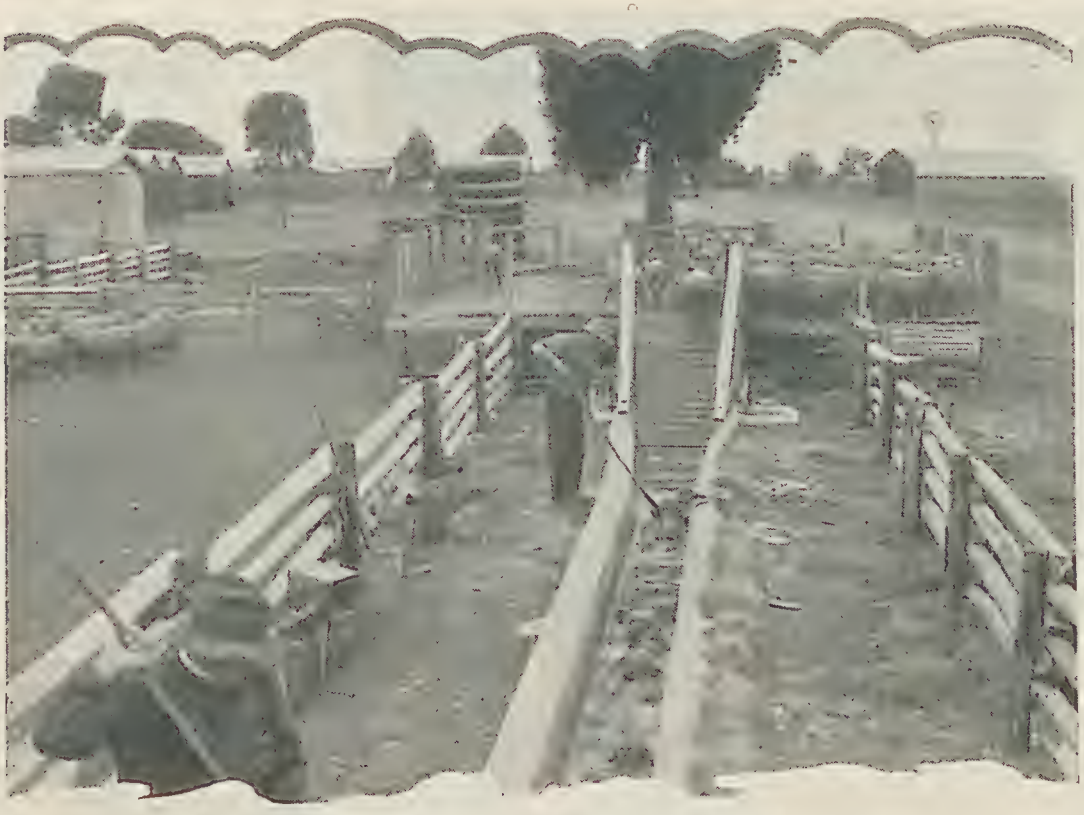


Sheep Dipping

Requirements of the Act

By R. N. Johnstone, B.V.Sc., Superintendent of Live Stock.

AS the shearing season approaches it becomes necessary to remind sheep-owners once again of the requirements of the Sheep Dipping Act which is in force in Victoria. Under this Act every sheep-owner in the State is required to dip all his sheep immediately after shearing and directly from the shearing board. All lambs must be dipped at the same time. If it is not convenient for the sheep to be dipped direct from the board the Act provides that they must be kept in a securely fenced paddock and dipped within 60 days after shearing.

Within 30 days of dipping a return on the prescribed form, available from the Department of Agriculture, must be forwarded to the Chief Inspector of Stock. Any sheep-owner who refuses or fails to satisfy an inspector that his sheep and lambs have been duly dipped is liable to a penalty. In the Act, "dip" or "dipped" means that the animals must be thoroughly immersed in some effective and approved preparation for destroying vermin. Refusal or neglect to shear sheep and lambs annually (except lambs to be kept as hoggets) constitutes a breach of the Act.

An inspector may require an owner to muster his sheep and lambs for the purpose of inspection, but such muster cannot be ordered between 1st April and 13th September. An owner may be ordered to dip within fourteen days a flock in which sheep have been found carrying ticks or lice. Failure to comply with such an order renders the owner liable to a penalty of £10. If this order is not complied with within seven days of a conviction, the owner is liable to a further penalty of from £5 to £20 and so on for each succeeding conviction.

This ewe, infested with lice, has rubbed along a barbed-wire fence till her wool has been torn from back and sides.

If a person in charge of travelling sheep finds any carrying ticks or lice and unable to travel he must take them in a conveyance or leave them in the care of some person. They must not be left upon any road or the land of any sheep-owner. Such sheep must not be abandoned without being destroyed, i.e., killed, and either buried, burned, or boiled down. Sheep carrying ticks or lice must not be travelled by road or taken to any public place or saleyard.

These regulations are necessary to protect careful owners of sheep, and during the past few years the administration of the Act has been carried out more rigorously, and it is the intention of the Department to be even more strict this year. Offenders will be fortunate if they escape prosecution.

Some owners and stock agents are under the impression that fat sheep or lambs forwarded for sale in fat pens need not be dipped before despatch. This belief is quite incorrect. Many graziers buy sheep in fat pens as forward stores or for topping off, and should these sheep be infested with tick or lice the parasites may be communicated by them to clean flocks. Therefore owners of infested sheep found in fat pens are just as liable to prosecution as those owners who offer their sheep in store pens.

The life histories of the sheep tick and sheep louse, and the means by which these parasites are spread from one animal or one flock to another are not clearly understood by all sheep-owners. Their presence usually is indicated by the rough appearance of the wool caused by the sheep scratching and biting at their wool, or by rubbing against hard objects, such as logs and fences, to allay the irritation caused by these parasites.

The sheep tick is not a true tick; it belongs to a family of two-winged flies. Ticks live in the wool and frequently on hot days they come to the surface, and may be seen on the sheep's back and sides basking in the sun. They feed by inserting their proboscis or snout into a skin pore, where a wound is made by the rough edge of the proboscis and the blood sucked up. The mature female

Photos—South Australian Department of Agriculture.]

The same ewe twelve months later after shearing and dipping.

lays an egg which contains a fully developed larvae. At first the egg is white, but within a few days it shrivels slightly and turns a dark-brown colour. It remains in this pupating stage for from 19 to 25 days, when a fully formed tick emerges. These tick reach maturity in about four days, and on about the 14th day the female lays eggs and so the life cycle is complete.

A great deal of discussion has centred around the length of time live ticks can remain alive on fences or in sheds away from the sheep, and many experiments have been carried out in order to throw light on this question. In many European and American experiments, all ticks died within four days after being parted from the sheep, but different results were obtained in experiments carried out by Drs. Sweet and Seddon at the Melbourne Veterinary School. In these tests, 151 ticks were collected and kept under varying conditions. Two, which had been kept on soil in a cellar, died on the 11th day; all the remainder died previously, the majority within three days. In a later experiment carried out by Dr. Hill, one lived for eighteen days on a piece of wood covered with bark and kept in sheep-pen sweepings. As a result of these experiments, we can say definitely that three weeks is the maximum period of existence apart from a live sheep, and that whilst the usual method of spread is from one live sheep to another, sheep may become infested if placed in sheds or yards where infested sheep have recently been kept.

A barbed-wire fence along which sheep infested with lice have rubbed.

The sheep louse (Trichodectes) is a biting variety. It is very small—about one-thirtieth of an inch long, and owing to its greyish-pink colour, it is extremely difficult to see this louse against the pink skin of a healthy sheep. Sheep lice are found usually about the front of the shoulder blade or on the neck. In searching for them do not look on the wool fibre, only eggs will be found there. Open the wool wide with the direct sunlight on it, and the louse will be seen right on the skin. It is extremely active, and is endowed with marvellous fecundity and tenacity of life. It never leaves its host unless it can transfer to a fresh victim in contact. This it does with great rapidity, and one infested sheep will thus infest a whole flock in a very short period of time.

The females lay eggs which hatch in five to seven days, and within about fourteen days of hatching the louse is fully developed, and the female lays enormous numbers of eggs. Thus the life cycle is complete in about eighteen days. The louse lives on the skin, and when feeding bites through the skin, causing intolerable irritation. The louse causes much more damage to the fleece than does the tick, and also is much more difficult to get rid of.

Fortunately, flocks may be kept free from these parasites without great difficulty, for careful attention to dipping will completely rid the sheep of ticks and lice and check the damage caused by these pests.

It is desirable that sheep-owners should construct a dip on their own properties. Driving to and from a public dip or a neighbour's dip is good neither for the sheep nor for the dipping.

If a powder dip is being used, mixing is a most important matter. Measure accurately the quantities of powder and water and see that both are properly combined. The time devoted to mixing will be well repaid. Never guess the contents of a bath. On no account put dry powder into the dip. Never use hard water with liquid dips.

The Act does not prescribe what dip shall be used; all that it asks is that the dip shall be effective, and the owner is allowed a free choice of the many proprietary dips on the market; or he may even prepare his own dipping mixture. If sheep are found infested with ticks or lice, the fact that they have been dipped does not relieve the owner of responsibility.

Proprietary dips at present on the market may be divided into two main classes—those which destroy parasites in the process of feeding and are known as poison dips, and those which destroy parasites by coming in contact with the external surface and are known as contact dips. Some makers have prepared a combination of these two main classes in varying proportions. Most of these dips are undoubtedly efficient for the purpose

for which they are sold, although some are doubtful, and do not justify the claims made for them. The active ingredient of poison dips is almost invariably arsenic in one form or another, while that of contact dips is cresylic acid or some other coal tar derivative. These dips vary considerably in their lasting properties on the sheep's skin, and as the practical value of dipping depends not merely in killing the insects which are alive at

Mature Male Sheep Tick (enlarged).

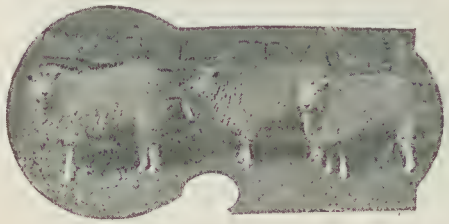
the time of dipping, but also on the duration of the period over which sufficient dip will remain in the fleece to destroy the parasites which hatch out subsequent to dipping, those dips which last the longest are the most desirable. One criterion for guidance is their relative solubility. If a dip is readily soluble, it is probably wanting in lasting effects; therefore sheep-owners will be well advised to use dips which mix slowly in preference to those which dissolve quickly.

Sheep Louse (enlarged).

The essential points of the operation of dipping are absolute care and thoroughness. Stir the dip thoroughly before putting the sheep into it, and keep it stirred while dipping is in progress. Don't put overheated sheep into the dip. Care must be taken to thoroughly saturate the animal to the very skin. Check the sheep when swimming through by gently pushing them back once or twice; this opens the fleece and helps the dip to penetrate. Quickly push their heads under twice with a crutch, but don't hold them under. Drain the sheep thoroughly before allowing them on to pasture. Dry in the shade if possible; drying in the sun sometimes causes scalding, as will also heavy rain. It should be borne in mind that unfavorable conditions, such as heavy rain soon after the operation, may wash out much of the dip and thus militate against complete success.

A clean muster is essential. Any sheep or lambs left over at dipping will carry the parasites and will reinfest the dipped sheep when the protective effects of the dip are lost—usually within a few weeks.

In the case of sheep which are badly infested with lice, it is advisable to re-dip the sheep within fourteen days in order to destroy lice which have hatched out of the eggs after dipping, and which have not been destroyed by the dip, and therefore remain in the fleece. If longer periods are allowed, the female will have become sufficiently mature to have laid eggs and thus render yet another dipping necessary.



"Melilotus" Seed in Wheat

Effect on Flour

By W. R. Jewell, M.Sc., Agricultural Research Chemist

IT has been stated recently that "melilotus" seed, when mixed with wheat, imparts a decided taint to flour milled from such a mixture, and even to flour milled from wheat that has been in contact with melilotus seed. To investigate the matter, parcels of wheat were mixed with ¼, ½, 1, 2, and 5 per cent. melilotus seed respectively, divided into three sets, and then stored in air-tight jars under the following conditions:—One set of samples was stored for a month; another for three months. The third set was wetted with 6 per cent. moisture, left for a week, dried at air temperature, and then stored for three months.

At the expiration of the storage period each sample was divided into two parts, one to be milled direct and the other after the separation of the melilotus. It was intended to bake a loaf from the flour from each milling and examine it for taint while in the oven, while still hot, and after cooling. When opened, all the mixtures had a decided smell of Hexham scent, as was to be expected.

Flour Milled from Wheat Containing Melilotus.

On milling the sample containing ¼ per cent. melilotus, which had been stored for one month, it was found that the flour had a decided taint. The taint persisted, and the bread made from the flour had both a smell and a peculiar taste. In view of this result, the remaining samples containing increasing proportions of melilotus were not milled.

It, therefore, appears quite definite that wheat milled when mixed with as little as ¼ per cent. melilotus will yield a flour with a decided taint, apparent also in the bread baked from such flour.

Flour Milled from Wheat after Removal of Melilotus.

Melilotus was carefully removed from the set of samples stored dry for one and three months respectively, and the cleaned wheat milled. In no case could any foreign smell be detected in the flour. Baking tests were then made, and loaves from wheats which had been in contact with ¼, ½, 1, and 2 per cent. melilotus respectively were entirely free from smell and taint. The loaf from the 5 per cent. mixture showed a scarcely discernible foreign smell.

As it would be impossible in practice to procure commercial wheat containing anything approaching such a high proportion of melilotus seed as 5 per cent., it is concluded that flour from wheat which had been in dry contact with melilotus for periods up to three months is free from taint, provided the seed is efficiently removed prior to milling. Longer storage under commercial conditions would not be expected to develop a taint in view of the negative results in three months with relatively high contamination.

Moistened Samples.

The samples in which melilotus was mixed with moistened wheat were freed from the melilotus, milled, and a test loaf baked. Those which had contained 5 per cent. melilotus yielded flour with a very faint smell of Hexham scent, and with a discernible taint in the bread. Wheat from the 2 per cent. mixture yielded flour with no apparent smell, but the resulting loaf had a very faint foreign taste. Wheat from mixtures containing less than 2 per cent. melilotus yielded flour satisfactory in every respect.

It would appear that there is a risk of tainted flour when wheat is mixed with melilotus seed under damp conditions, such as exposure to rain after bagging. As, however, 2 per cent. melilotus is a relatively high contamination, not likely to be experienced in commercial wheat, the probability of this occurring is very small.

[*Continued on page* 417

Poultry Disease Control

The Breeder's Part

By R. N. Johnstone, B.V.Sc., Superintendent of Live Stock.

MY object in this brief article is to deal in a simple way with what I consider to be the problems confronting the man on the poultry-farm rather than with those of the experienced breeder of pedigree stock.

The first essential for the avoidance of disease in the poultry-yard is the production of sound stock, and one question to be considered to-day is: Are we breeding too much for big records in laying tests, and not sufficiently for good health and average production on the commercial farms? Another question which arises is whether the commercial poultry-farmer should buy or breed his stock. There is a tendency in these days of low prices to mate birds with the object of producing fertile eggs, but without giving much thought as to the quality of the stock those eggs will produce. If the people who follow this practice kept the chicks hatched on their own farms, any trouble encountered would be localized, but the sale of eggs or of chicks bred in this manner means that birds of weak constitution are spread to many farms. I think that if the commercial poultry-farmer has the time, knowledge, and equipment to breed his own stock, it is advisable for him to do so, but if he decides to purchase, let him be suspicious rather than sorry, and make certain, as far as possible, that he is getting chicks from sound and healthy birds. Stock to be used for breeding purposes must be carefully selected. Nothing should be allowed to interfere with selection for excellence of general health, vigour, and strains. Body size must be such as will accommodate all the internal organs comfortably, and so allow plenty of room for the elaboration of food into egg material. Breed type in general may be adhered to, but should not be allowed to supersede excellence in other directions.

In selecting a hen for a breeding pen, her total egg production should not come first in the list of requirements. Individuals which are members of large families, all of which have yielded well, are preferable to stock from very high, but isolated producers.

Secure chicks from sound, healthy birds.

The wisdom of breeding from pullets must be considered. Is this practice responsible for some of our present troubles? To this question, it is not possible to give an unqualified yes or no. If the mortality in the average trap-nest house is similar to that in laying trials, 12 birds out of every 100 will die. A large proportion of these twelve will die after producing a number of eggs, and unless these are traceable, stock will be raised from birds which have died from one cause or another before completing their first year's lay. For every hundred pullets put under test in March, 1933, there will probably be not more than 70 from which one would care to breed in July, 1934; yet under a system of pullet mating eggs from many of the rejects may be used for breeding purposes. Breeding from second-year birds certainly has its disadvantages, but these

are compensated for by the fact that all birds of weak constitution have been eliminated. They have been through a difficult period of moult, and come into production in good form. Something is known of them, and they can be relied upon to produce sound stock.

Having selected breeding stock, what system (in general terms) must be used for future breeders—battery, intensive or grass runs, or what combination of them? One hears that chicks bred under the battery and intensive systems are unsuitable for future breeding stocks. Is there any reason for this opinion? Or is it simply a prejudice due to the fact that the birds are reared in a way as yet unfamiliar to most? Some breeders go so far as to hen-hatch and hen-rear eggs from their very best birds. From the hen to the battery is a far cry. Much has been written about disease in chicken-rearing, and the best way of reducing chances of infection, or for effecting cures. It may be that by using artificial means a number of chicks which, under old-fashioned practices, would have died, are kept alive. One writer claims that natural systems of rearing tend to cull out all the unfit. He points out that the thin-shelled or faulty egg is broken by the hen during incubation, and that the chick which is too weak to get out of the way of the hen's feet is killed. Perhaps with our artificial methods, we are making life too easy for the chicken.

When stock for breeding, or indeed any stock, is being raised, it is the height of folly to coddle the chickens. If they have not sufficient strength to grow and thrive under conditions of suitable housing, feeding and management, they are not worth rearing, and should make room for healthier birds.

It is probable that conditions will become even more artificial in future than they are at present. It is all a question of economics, and bound up with our fight against disease. If we cannot afford to go back to nature, we must endeavour to perfect the artificial conditions which are necessary. Incubator houses and incubators must be properly ventilated. I do not think many poultry-farmers realize the enormous losses which are caused by faulty ventilation, and lack of oxygen. Even those chicks which survive this ill-treatment are weak, and not likely to develop to healthy maturity. These remarks apply also to brooders. Apart from contagious disease, the main cause of mortality amongst chickens during the brooder stage is bad ventilation associated with sweating.

Dampness of litter is more often caused by an excess of carbon di-oxide than by too high a temperature, or by any other cause. The temperature also must be well regulated. Before the chicks are put in, and for the first few days, the brooder should run at 95°F., after which it should drop about 4° weekly until the sixth week, when artificial heating should be dispensed with. Even moderate changes in temperature may produce digestive and intestinal disorders. If an unusually high rate of mortality occurs during the brooder stage, early and accurate diagnosis of the cause is essential.

Before calling in the aid of the veterinary pathologist, the breeder should carefully note all the circumstances surrounding the outbreak. Cases are on record in which, after extensive laboratory research had failed to determine the cause of the mortality, inquiry at the farm furnished the explanation.

If undigested food be found in a chick which is debilitated through lack of oxygen, commonsense should suggest that the food was not the primary cause of death. But in the laboratory, it cannot be determined whether death was due to a lack of oxygen or to some trouble caused by defective heating apparatus. The decision then must be made on the evidence produced, and assuming that all other conditions were normal, indigestion or the absence of any other disease would point to faulty food.

If a careful investigation fails to reveal the cause on the farm, several of the live sick birds should be sent to the Director, Veterinary Research Institute, Parkville, N.3. Subjects typical of those showing signs of disease should be chosen. At the same time as they are sent a complete description of the outbreak should be supplied, stating when the first sickness was noticed, and giving every detail of the number, age, and type of birds affected, the symptoms shown at all stages, the duration of the disease, that is the period which elapsed between the first symptom and death; the number of recoveries, if any, and the post-mortem appearance. For this purpose a number of the dead birds should be opened, and every departure from the normal noted and supplied. The feeding and housing methods adopted must be stated, with particulars of any recent changes; the source of origin of the affected birds, or, if they were reared on the farm, whether they have been in contact with birds recently introduced from other sources; or, if chickens,

[Continued on page 432.

The Vegetable Weevil

(*Listroderes costirostris* Gyll)

By R. T. M. Pescott, M.Agr.Sc., Entomologist

THE Vegetable Weevil, as the name suggests, is primarily a pest of vegetables; carrots, turnips, potatoes and tomatoes being the most severely attacked. Considerable damage is caused to these plants by both the adult beetle and the larval or grub stage.

This insect is almost certainly a native of Central America, it having been recorded from Southern Brazil in 1834. It was first recorded from Australia in 1908 when it was found to be damaging various vegetable crops throughout the southern and eastern portions of the continent. At this time it was known popularly as the Tomato Weevil, and scientifically as *Desiantha nociva* Lea. In 1922, a weevil became established in South-eastern United States of America and finally, in 1926, was found to be fairly widespread in California, attacking many types of vegetables. An examination of infected plants and of the insects responsible for the trouble revealed that this insect was identical with the Australian Tomato Weevil (*Desiantha nociva* Lea). It was found, at that time, that this name (*Desiantha nociva* Lea) was synonymous with the name *Listroderes obliquus* Gyll and still later it has been found that the correct naming should be *Listroderes costirostris* Gyll. It was in California that attention was drawn to the fact that the name Tomato Weevil was rather too restricted in describing the habits of the insect, as, in addition to tomatoes being attacked, potatoes, carrots, turnips and spinach also are damaged. Consequently, the name was changed to the broader title, *Vegetable Weevil* and it is felt that this more correctly describes this weevil. It is also now recorded as a pest of vegetables from New Zealand where it apparently has been established for many years.

New Zealand Journal of Agriculture.]

Fig. 1.—Showing carrot leaves injured by the vegetable weevil.

Habits and Nature of Injury.

The weevils are gregarious in habit, and rather slow moving. They have well-developed wings, but there are no authentic records of the beetles having been observed in flight. These insects make good use of their legs and cover a considerable area of ground, particularly at night time, when they are most active. While actual distribution of the species from one locality to another may occur in this manner, the most potent factor in their widespread dissemination is that of the agency of man through their carriage from place to place on host plants.

Both the larvae and the adult beetles are nocturnal feeders, while during the daytime these two forms are to be found about the bases of the host plants or under nearby clods and rubbish.

The principal injury to vegetables is a stunting of the plants, caused by the eating away of the tender young crown leaves. Carrots and turnips are preferred as food plants by the insect in the larval or grub stage. When the former plant is

Fig. 2.—Showing turnips injured by the larvæ of the vegetable weevil.

attacked, only the large stems and heavy veins of the leaves are left as shown in Fig. 1. In the latter host, however, quite apart from the destruction of the leaf surface, a severe gouging-out of the turnip bulb at ground level may occur, or even a partial destruction of the underground portions of the plant (see Fig. 2). On the other hand the adult insects, instead of attacking carrots and turnips as their main food supply, prefer young tomato and potato plants. The beetles eat through the stem of these plants at the ground surface, but when the plants are more mature, they ascend the stems and eat the leaves or cut the stems just below the bud. In this way, they cause a type of damage very similar to that of the common cutworm.

Plants other than those previously mentioned which are attacked by the Vegetable Weevil include spinach, radishes, parsnips, celery, parsley, cauliflowers, cabbages, kale, kohl rabi, lettuce, onions, leeks and the leaves of artichokes. Quite apart from these economic plants, several species of weeds are attacked, and it is this factor which, while so often neglected, is responsible for the continuation of the trouble in individual gardens from year to year. Chief among these weeds are the common cape weed (*Cryptostemma calendulaceum*) and the marsh mallow (*Malva rotundifolia*).

Life History.

During the warm summer months and in early autumn, the adult or beetle stage of this insect is predominant, but is present in an inactive or dormant stage. From about mid-March until mid-September, these beetles are actively laying eggs. It is a remarkable fact that up to the present time no male insects of this species are known, the females therefore being parthenogenetic (i.e., producing fertile eggs without fertilization by a male insect). The eggs when first deposited are white, spherical and about one-twenty-fifth of an inch in diameter. These eggs gradually change colour until just immediately before hatching, they are almost black. The insects prefer a moist place for egg laying, and from 1 to 30 eggs per day may be laid by each insect with a total range of from 300 to 1,500 eggs per insect in a season. Where carrots and turnips are concerned, egg laying usually takes place on the crown of the plant, though eggs may be laid on the leaves or on the soil near the base of the plant. On an average, from 11 to 24 days is spent in the egg stage.

On hatching from these eggs, the larvae or grubs are of the usual weevil form, being slender, strongly curved, legless and of a creamy white colour when first hatched. As they grow, the body colour changes from creamy white to green owing to the presence of food which they ingest (see Fig. 3). By the middle of winter, it is no uncommon sight to see from 5 to 12 larvae feeding in the crown of one host plant. After four distinct moults, or shedding of skins, the larvae become fully grown, leave the host plant and enter the soil. After the mature larvae enter the ground, they form cells of earth about 1 to 2 inches under the surface, in which, after undergoing another moult, they enter the pupal stage (see Fig. 4) which usually occupies from 14 to 16 days. This stage is perhaps the most critical

Fig. 3.—Larvæ of the vegetable weevil—about four times natural size.

period in the life history of the insect—the pupa being so very delicate that only the slightest pressure is required to rupture the body wall and cause death. This fact is made use of in the control of the insect by cultural methods.

The adult insect (see Figs. 5 and 6) remains in the soil in the pupal chamber for several days after the transformation from the pupa, in order that the body covering may become hardened. The perfect insect then emerges from the soil and seeks food. The adult is about one-third of an inch in length and about half as wide. The snout or beak, characteristic of weevils and protruding from the front of the body, is short and stout and bears elbowed antennae. The colour is a dull greyish brown which blends very well with that of the soil, and conceals the adults when they are resting on the surface of the ground during the daytime. On the wing covers, there is a well defined V-shaped figure of lighter colour, while at the back of this V-shaped mark, and on either side of it, is a pair of tubercles which project backwards (see Fig. 5). The weevils being gregarious in habit collect in large numbers around the stems of young potato plants, and also under boards or rubbish about infested areas.

Control Measures.

Measures for the control of the vegetable weevil can be considered under the following headings—(*a*) cultivation, (*b*) crop rotation, (*c*) field sanitation, (*d*) the use of poison baits (*e*) the use of poison sprays or dusts.

Cultivation.—During the months July to October, a large percentage of the immature

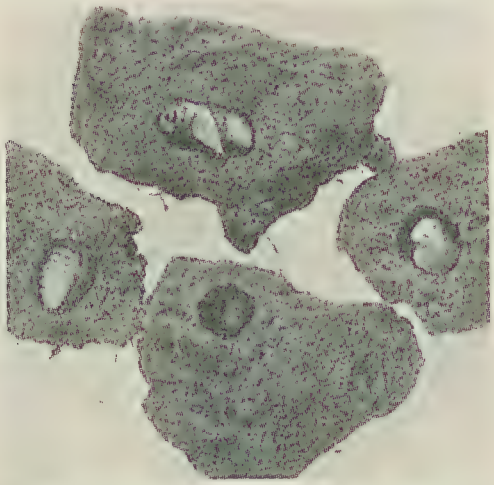


Fig. 4.—Pupæ of the vegetable weevil as they appear in the cells which are one or two inches below the surface of the soil.

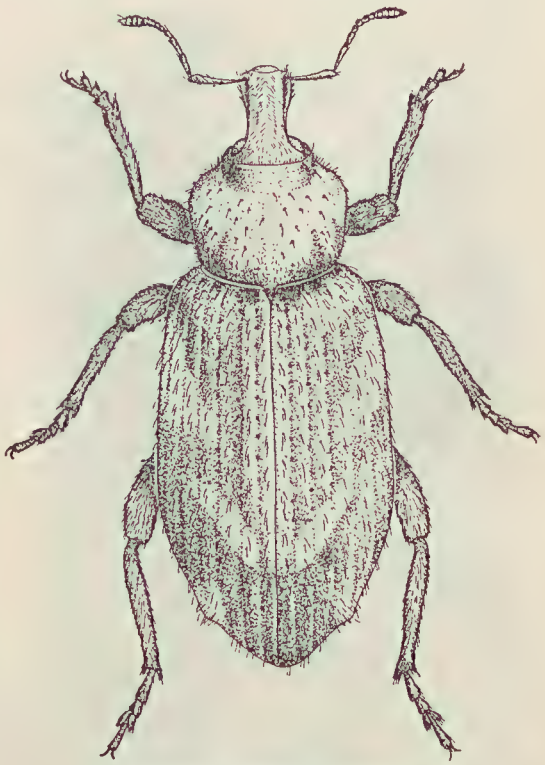


Fig. 5.—The adult vegetable weevil.

insects are in the ground usually a few inches only below the surface in either the pupal or early adult stage. As described previously the insects are practically motionless and very delicate in this stage; and the slightest pressure brought to bear on them will rupture the body and cause death. Therefore, thorough and repeated cultivations of infested areas during these months with a disc or harrow, followed with a spiked roller will break up the pupal cells and kill the insects. This tends to lessen greatly the adult population in the following spring and early summer.

Crop rotation.—In the autumn and early winter, the larvae of the vegetable weevil are most active and all the damage caused by the larvae to vegetable crops is done at this period. Host plants, such as turnips and carrots, if grown in succession will cause an increase in weevil population. However, if areas known to be infested are planted to crops which are immune to weevil attack, the insects would then be forced to leave the field, or to starve for want of proper food. The larvae or grubs being legless cannot travel far and since the adults do not fly, they cannot seek food at long distances. On the other hand, if fields of tomatoes or potatoes are planted in the spring immediately adjacent to land that was heavily infested during

Fig. 6.—The adult vegetable weevil about four times natural size.

the previous autumn and winter, severe damage can be expected from the adult weevils.

Field sanitation.—During the summer months, the adult weevils go into hiding and remain inactive until early autumn. For this purpose, almost any kind of shelter that the insect can find, such as rubbish or grassy and weedy headlands is preferred. In the autumn, the weevils begin to lay their eggs upon the first host plants suitable for the larvae. In the majority of cases, the first larvae and the most severe injury to vegetable crops will be found immediately adjacent to those places where the over-summering forms were allowed to shelter.

In Victoria, this pest commonly occurs when cape weed and marsh mallows are allowed to grow without being checked, particularly in the region of headlands. In view of these facts, a great deal of the danger of insect injury would be removed if fence lines were kept clean and all weeds and rubbish completely eliminated from the areas in which the crops were growing.

Poison Baits.—Once the adult weevils and larvae are established in a plot of vegetables, very little can be done in the way of mechanical measures to eradicate the pest. Very great success, however, can be obtained by the use of poison baits. Poison baits consist essentially of some attractant medium to which has been added some form of stomach poison such as arsenate of lead, arsenate of calcium or Paris green. One method of preparing a poison bait quite commonly in use, is to cut carrots or turnips up into fairly small pieces, and then to dip them into a solution of arsenate of lead, 1 lb. in 20 gallons of water. These treated pieces are then broadcast over the affected areas. It will be found that the larvae and adults are attracted to the cut surfaces of the vegetables and die after obtaining a dose of the poison. This bait is of particular use in the spring against the adult weevil on tomatoes and potatoes.

Another poison bait, and one which proves very successful, is made up as follows :—

Bran 10 lb., juice of 12 lemons, arsenate of calcium 1 lb., or Paris green 4 oz.

The bran and arsenate of calcium or Paris green are firstly mixed together in a dry state, and then the lemon juice, diluted with a small quantity of water, added until the whole mixture takes on the appearance of a wet mash. This should then be scattered around infected plants during the spring, the baits being put out preferably in the late afternoon or early evening so as to prevent excessive drying out by the sun.

Poison sprays or dusts.—Poison sprays or dusts, usually of an arsenical nature, can be used to control both destructive stages of the vegetable weevil. As far as potatoes and tomatoes are concerned, when the first signs of damage are noticed, usually about November, the plants should be dusted with either a 25 per cent. lead arsenate dust, or a 20 per cent. calcium arsenate dust, or else sprayed with a lead arsenate spray, 1 lb. to 16 gallons of water. One thorough application of either of these materials should be sufficient, but if subsequent damage is noticed, it may be necessary to repeat the treatment. It is always a wise precaution to dip young tomato plants in the arsenate of lead solution before planting out as this will keep cutworms in check, as well as controlling the vegetable weevil.

When other vegetable plants such as carrots, turnips and radishes are attacked, the same materials, i.e., 25 per cent. arsenate of lead dust, 20 per cent. arsenate of calcium dust or the arsenate of lead spray, to which a spreader has been added, will be found effective. One treatment with either of these materials applied as soon as the larvae are first found, should suffice to prevent all damage from the vegetable weevil. In this case, it is usually found that dusting is more effective than spraying because of the better distribution of the poison among the plants.

Poultry Feeding Tests

By W. O. Pederick and A. G. Clark

EXTENDING over the eleven months from the 1st May, 1933, to the 31st March, 1934, several poultry feeding tests were conducted at the State Research Farm, Werribee.

For the purposes of ten tests 500 pullets were selected, consisting of 250 White Leghorns, which were divided into five pens of 50 each, and 250 Australorps, similarly divided. The Australorps averaged 164.3 eggs per bird; the White Leghorns 160.8 per bird. The average wholesale price for eggs during the test was 1s. 0¼d.

The cost of food, based on the ruling wholesale price for the different foodstuffs, amounted to 3.7d. per dozen eggs laid; the cost per bird per week was 1.05d.; the quantity consumed per bird per day was 3.5 oz., and for every egg laid 7.1 oz.

The gross profit, or the profit over food cost, was 9s. 7½d. per bird. This figure shows that, notwithstanding the poor price of eggs, there was a fair margin of profit; this was made possible by the low cost of food.

These tests, as well as many others that have been conducted at Werribee during the last thirteen years, demonstrate that when feeding pullets for egg-production, satisfactory results can be obtained from rations varying considerably in composition.

Dried buttermilk and meat meal are concentrates and are used to balance the ration, but a study of the amounts consumed in the different pens shows many contradictions. In pen 2 (Australorps) 230 lb. of dried buttermilk with ground grain produced an average of 163 eggs per bird. In pen 4 (Australorps), where 100 lb. of dried buttermilk was eaten with bran and pollard, the average number of eggs per bird was 164. In pen 7 (White Leghorns) 247 lb. dried buttermilk was eaten with ground grain, and the average number of eggs laid per bird was 160. In pen 9 (White Leghorns) 183 lb. dried buttermilk with bran and pollard produced 163 eggs per bird. In pen 1 (Australorps) 202 lb. meat meal was eaten with ground grain, and the number of eggs laid was 178. The White Leghorns in pen 3 ate 130 lb. meat meal with bran and pollard, and the number of eggs laid by each bird was 168. In each of pens 8 and 10 (White Leghorns) 160 lb. meat meal was consumed; in pen 8 the birds had bran and pollard, and averaged 153 eggs per bird. In pen 10 ground grain was supplied; the average in this pen was 168.

In free choice feeding, birds always consume much more grain than meal, and unless a large amount of animal food—meat meal or dried buttermilk—is taken, the balance of the ration is upset and production may be affected.

If birds are to lay a large number of eggs they must eat a large amount of food, and to induce that consumption, the food must be palatable. When pullets are bred from proved laying strains and are properly managed, there is very little danger of over-feeding. Wheat is the most palatable of grains, and is usually the staple grain food, but fairly large quantities of three other grains—oats, maize, and barley—were consumed in the test. These grains all have good feeding value, and should be used to add variety to the ration, though, of course, one always must take price into consideration when deciding on the proportions to be used. Barley is the least palatable of whole grains, but when ground is liked better than ground oats; ground oats, however, are not so tasty as whole oats.

A statement giving particulars of the feed supplied to the different pens, the total cost of the feed, and the value of eggs from each pen is given on the next page.

Poultry Feeding Tests.

AUSTRALORPS AND LEGHORNS. DURATION OF TESTS—11 MONTHS.

Pen.	Breed.	Food.											Total Food.	Cost of Food.	Eggs.	Value of Eggs.	Profit over Cost of Food.
		Bran.	Pollard.	Ground. Wheat.	Ground. Oats.	Ground. Barley.	M.C.C. Meat Meal.	Dried Buttermilk.	Wheat.	Oats.	Maize.	Barley, Six Months only.					
		lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	£ s. d.		£ s. d.	£ s. d.
1	Australorps — Free Choice ground grains meat meal and grain	..	..	672	46	184	202	..	1,700	455	370	120	3,749	10 10 8	8,924	37 17 9	27 7 1
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**75**	**0 4 2½**	**178·5**	**0 15 2**	**0 10 11½**
2	Australorps — Free choice ground grains dried buttermilk, and grain	..	..	581	54	306	..	230	1,375	412	390	150	3,498	10 2 8	8,174	35 7 3	25 4 7
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**70**	**0 4 0¾**	**163·5**	**0 14 1¾**	**0 10 1**
3	Australorps — Free choice bran, pollard, meat meal and grain	264	340	..	..	..	130	..	1,695	539	520	180	3,668	10 2 11	8,419	35 18 2	25 15 3
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**73·4**	**0 4 0¾**	**168·4**	**0 14 4½**	**0 10 3½**
4	Australorps — Free choice bran, pollard dried buttermilk, and grain	276	300	..	..	..	..	100	1,590	494	500	210	3,470	10 3 3	8,214	35 1 7	24 18 4
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**69·4**	**0 4 0¾**	**164·3**	**0 14 0½**	**0 9 11½**
5	Australorps—Dry mash and free choice grain	215	215	..	..	..	48	..	1,506	427	560	140	3,111	8 12 7	7,358	32 2 7	23 10 0
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**62·2**	**0 3 5½**	**147·2**	**0 12 10¼**	**0 9 4¾**
6	White Leghorns—Dry mash and free choice grain	..	..	230	230	230	76	..	1,900	392	430	250	3,738	10 4 10	7,888	32 15 8	22 10 10
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**74·8**	**0 4 1¼**	**157·8**	**0 13 1½**	**0 9 0**
7	White Leghorns—Free choice ground grains, dried buttermilk and grain	..	..	283	47	314	..	247	2,035	399	440	250	4,015	12 16 8	7,999	33 12 9	20 16 1
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**80·3**	**0 5 1½**	**160·0**	**0 13 5¾**	**0 8 4**
8	White Leghorns—Free choice bran, pollard, meat meal and grain	144	140	..	..	..	160	..	2,150	420	540	290	3,844	10 13 4	7,693	31 18 11	21 5 7
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**76·9**	**0 4 3½**	**153·9**	**0 12 9½**	**0 8 6**
9	White Leghorns—Free choice bran, pollard, dried buttermilk and grain	240	260	..	..	..	..	183	1,770	364	510	240	3,567	11 2 8	8,216	34 15 8	23 13 0
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**71·3**	**0 4 5½**	**164·3**	**0 13 11**	**0 9 5½**
10	White Leghorns—Free choice ground grains, meat meal and grain	..	..	279	69	172	160	..	1,705	469	540	250	3,644	10 6 11	8,423	35 19 8	25 12 9
	Average ..	..	..	..	..	..	..	..	..	..	..	..	**72·9**	**0 4 1¾**	**168·5**	**0 14 4¾**	**0 10 3**
	Total, 500 birds..	..	..	..	..	..	..	..	..	..	..	..	36,304	104 16 6	81,308	345 10 0	240 13 6
	Averages ..	..	..	..	..	..	..	..	..	..	..	..	**72·6**	**0 4 2¼**	**162·6**	**0 13 9¾**	**0 9 7½**

Orchard and Garden Notes

By Edward E. Pescott, F.L.S.

The Flower Garden.

THIS is the time to prepare for sowing seeds of all summer-flowering annuals, such as Phlox, Butterfly Delphiniums, Aster, Sunflowers, Cosmos, Zinnia. The bed should be placed in an open position, and the soil worked into a very good light tilth.

After sowing the seed, which is usually sown quite shallow, the bed should be lightly covered with a sprinkling of well-broken leaves, or very old manure.

Herbaceous perennials, such as Cannas, Delphiniums, Phlox and others, may now be planted. The soil should be well dug over and enriched with manure. These plants are not foragers, and therefore require their food quite close to the crowns.

Early planting will ensure early blooms; this is especially desirable in the case of Delphiniums, which should give three crops of blooms each year. To obtain these the plants should be freely manured, and as soon as the flowers commence to drop their petals the whole stem must be cut down to allow the new shoots to develop.

Watch Roses for aphis; wherever they appear spray with nicotine sulphate. It may be necessary to repeat the spray after a few days. If mildew shows and kills the tips of the shoots, the plants should be dusted with sulphur.

The Orchard.

The Doncaster experiments against the Summer Spot of Pears have proved conclusively that this disease can be controlled if the trees be sprayed with Bordeaux mixture at the 6–4–40 strength when the bud scales are first opening, and again at the same strength when the pink colour is showing in the petal opening. A third spray at 6–4–80, or half strength Bordeaux, should be given about three weeks after the fruit has set, and while it is still in an upright position.

Delphinium.

In order to minimize the spring attack of the Codling Moth, the various methods of work known as orchard sanitation should now be carried out. All windows of packing sheds should be provided with wire netting, so that moths emerging in the shed may be trapped and destroyed. Lures should also be placed in the sheds; fermented apple juice or a 10 per cent. solution of vinegar and water makes a good lure.

Second-hand cases and packing boxes should be overhauled and scalded in boiling water, 1 lb. of washing soda being added for every 20 gallons of water.

No bark should be left on props, and all rough bark should be scraped from the trees. Scrapings, cleanings and sweepings must be burned immediately.

The Vegetable Garden.

With the advent of spring, sowing the seeds of all plants of the cucumber, melon, and marrow family should be done. Included in this family are the choko, a whole fruit of which must be planted, and the so-called "Solomon Islands bean," which is merely a variety of a climbing vegetable marrow, and not a bean. Among cucumbers, the crystal apple-shaped is popular, and the plants are very prolific.

The succulent character of the fruits of all of these plants is an indication that they require an abundance of water all through the growing season. Further, the vigorous and abundant growth of the plants demands a full supply of plant food. Stable manure is by far the best food, and it should be supplied in abundance.

It is a common practice to set out the plants in a shallow depression capable of holding a good supply of water, and the manure may be filled into this hollow. When the plants are growing freely, the tips of the runners should be pinched out, so as to check their terminal growth, and so force them to send out lateral shoots on which the fruit is carried. The young plants should be protected from cold winds and from frosts, as they are readily injured and frequently killed by the action of cold or low temperatures.

"Melilotus" Seed in Wheat

(*Continued from page* 407)

Separation of Wheat from Melilotus Seed.

It has been alleged that it is very difficult, in fact almost impossible, to separate melilotus seed from wheat, but considering the extremely small size of the former compared with the latter, it is difficult to agree with this assertion, which is not supported by several local millers and mill engineers. It would appear to be a relatively simple matter to make a clean separation by the use of a suitable sieving operation, and a new mill in England, installed by Henry Simon Limited, has a cleaning plant guaranteed to be 100 per cent. efficient in removing melilotus seed.

Conclusions.

From the foregoing small-scale investigation, the following conclusions may be summarized:—

1. Wheat milled with a very small admixture of melilotus seed produces a tainted flour, the taint persisting in the final loaf.

2. Even when stored with extremely high proportions of melilotus, dry wheat does not yield a tainted flour when the melilotus is removed prior to milling.

3. Damp wheat with upwards of 2 per cent. melilotus, when stored for some time, may yield a tainted flour, even when the melilotus is separated prior to milling.

4. No great difficulty should be experienced in separating melilotus from wheat on a commercial scale.

5. In view of the contaminating influence of even a very small proportion of melilotus milled with the wheat, it is to be expected that wheat containing melilotus will be discounted by millers, as the slightest accident or inefficiency of the cleaning plant may produce drastic results.

Professional Papers

[This section is devoted to professional papers and articles of a scientific character.]

Investigations on Flag Smut of Wheat caused by Urocystis tritici Koern.—Part II.

By W. B. Miller, M.Agr.Sc., Inspector of Agriculture and C. R. Millikan, B.Agr.Sc., Science Field Officer

[*Part I. of this paper appeared in the July issue of the Journal*]

4.—The Effect of Manurial Treatment on Flag Smut Infection.

As a result of observational evidence, it has been known for some time that there is a tendency for a higher infection of Flag Smut in some Victorian districts than in others. Climatic conditions and cultural practices may be responsible, but the soil type and its reaction, as measured by its pH value, may exert a considerable influence. Alkaline soils are considered to be more favorable to the disease than acid soils, but the optimum degree of alkalinity appears to be uncertain. The great majority of Victorian wheat soils are alkaline, and heavy Flag Smut infection has been recorded on all types, though in the Mallee infection tends to be more severe on limestone land.

Laboratory tests conducted by Noble (44) showed that spores germinated in solutions with pH values varying from 3·6 to 7·1, the optimum germination occurring within the range 5·1 to 5·7. He concluded that "other conditions being favorable, the spores germinate most readily when in contact with slightly acid solutions." Freedom of spore germination, however, is not necessarily an indication of optimum conditions for infection or development of the disease.

In the case of *Ophiobolus graminis* Sacc, Webb and Fellows (69) demonstrated that the growth of the organism could proceed over a wide range of hydrogen ion concentrations, whereas previous results were rather conflicting, and indicated a tendency to optimum growth under alkaline conditions.

Investigations made at the State Research Farm, Werribee, by Foster and Vasey (20) on the incidence of Flag Smut in certain plots in the Permanent Manurial Field indicated that a definite relation existed between the application of lime and the severity of the disease. Frequent applications of lime increased the alkalinity of the soil from pH 5·5 to a maximum of pH 8·3, and the plots so limed showed the highest infection with Flag Smut. The plots treated with farm-yard manure and farm-yard manure plus lime have shown by far the greatest infection.

Further experiments confirming Forster and Vasey's findings regarding the effects of dressings of lime and superphosphate on Flag Smut infection have been carried out at Werribee on rows sown with infected seed. The results have indicated that dressings of lime do influence slightly the occurrence of the disease, the average increase due to lime being about 20 per cent. (74)

Effect of Manures Sown with Infected Seed.

To obtain further information as to the relation between manurial treatment and Flag Smut infection under various climatic and soil conditions experiments with several manures were conducted at the Mallee Research Station, Walpeup, in 1932 and 1933, and also at the State Experiment Farm, Rutherglen, in 1933.

Preliminary Experiment—Mallee Research Station, 1932.

Infected seed of six varieties was sown in half-chain rows, each variety being subjected to four different manurial treatments. The soil was a reddish sandy loam, and at sowing time (8th June) the seed bed was moist. Weather conditions were unfavorable, so that only a small infection developed, particularly on the more resistant varieties.

The average results of the counts on the susceptible varieties are shown in Table V. :—

TABLE V.—RESULTS OF MANURIAL TEST, WALPEUP, 1932, SHOWING THE AVERAGE PERCENTAGE INFECTION RESULTING FROM DIFFERENT MANURIAL TREATMENTS.

	Treatment.			
	No Manure.	Superphosphate.	Superphosphate and Lime.	Superphosphate and Stable Manure.
Infection, per cent.	9·3	2·7	4·5	10·7

The application of superphosphate reduced infection considerably, while the addition of stable manure increased the infection.

Manurial Experiments, 1933.

The number of manurial treatments at Walpeup and Rutherglen was increased considerably in 1933. To obtain as wide a variation in soil reaction as possible, sulphuric acid and sulphur were included. These were applied to the soil one month before sowing in quantities calculated to cause the same change in pH of the soil at both centres. The change, however, was not as great as had been expected. Infected seed of Free Gallipoli was sown in the treated rows, approximately 200 grains per row, and each treatment was replicated three times. In addition the effect of superphosphate on the disease was studied at Longerenong and Warracknabeal. Soil samples for pH determinations were taken at sowing time from the different rows.

An outstanding feature of the growth of the manurial rows at Walpeup was a marked response to ammonium sulphate, the plants in these particular rows being much more vigorous than any other. This is in accord with experience in the Mallee regarding the effect of dressings of nitrogenous fertilizers on wheat, which indicates that on the more sandy areas particularly, an application of nitrogen often tends to have a beneficial effect upon both the growth and yield of the plant. There were no noticeable differences in growth between any of the other treatments at Walpeup, except that there was a slightly better tillering in the rows receiving superphosphate.

At Rutherglen tests on fallowed land over a number of years have shown that the effect of nitrogenous manures on the yield of wheat is small (23), compared with that at Walpeup. Germination of the "no manure" and ammonium sulphate rows was slow, the first to show out being superphosphate and the combinations containing superphosphate. The sulphuric acid rows germinated as quickly, but the plants were spindly before tillering commenced.

A high degree of infection developed in these experiments, and the results of the infection counts are recorded in Table VI. The standard error of a single treatment at Rutherglen and Walpeup was obtained in accordance with the method developed by Fisher and Wishart (18).

TABLE VI.—RESULTS OF FLAG SMUT MANURIAL TESTS, 1933, SHOWING THE pH VALUES AND AVERAGE PERCENTAGE INFECTION RESULTING FROM THE DIFFERENT MANURIAL TREATMENTS.

Treatment.	Rutherglen.		Walpeup.		Longerenong.		Warracknabeal.	
	pH.	Percentage Infection.	pH.	Percentage Infection.	pH.	Percentage Infection.	pH.	Percentage Infection.
No Manure	7·7	83·4	8·6	72·9	8·7	24·7	8·6	63·6
Superphosphate, 1½ cwt. per acre	7·6	62·4	8·1	72·3	..	23·5	..	60·3
Ammonium sulphate, 1½ cwt. per acre	7·8	73·6	8·0	43·9	..	..	..	..
Sulphuric Acid	7·2	33·2	8·2	70·5	..	..	..	..
Sulphur	..	40·6	8·4	69·7	..	..	..	..
Lime, 20 cwt. per acre	8.5	81·6	8·7	65·5	..	..	..	..
Potash, 1½ cwt. per acre	..	66·2	8·5	76·5	..	..	..	..
Superphosphate + Ammonium Sulphate	..	51·1	..	61·7	..	..	..	..
Superphosphate + Lime	..	78·9	..	68·1	..	..	..	..
Superphosphate + Sulphuric Acid	..	64·5	..	67·3	..	..	..	..
Superphosphate + Sulphur	..	62·1	..	63·3	..	..	..	..
Farm-yard Manure, 20 cwt. per acre	..	29·9	..	..	..	..	..	..
Standard Error	..	5·3	..	2.3	..	..	..	..

Various manurial treatments brought about large differences in infection, but these differences were not consistent at all centres.

At Rutherglen, significant decreases in infection, as compared with "no manure," were caused by all treatments except ammonium sulphate, lime, and superphosphate + lime. The greatest decrease resulted from a dressing of farm-yard manure, but sulphuric acid and sulphur also caused very significant responses.

The variations at Walpeup were not as great as those produced at Rutherglen, the outstanding change at this centre being the large decrease in infection which resulted from a dressing of ammonium sulphate. The only other significant decreases were produced by lime, superphosphate + ammonium sulphate, and superphosphate + sulphur.

From the experience at Werribee, Walpeup, and Rutherglen it would seem that the application of lime to the soil has a stimulating effect upon the disease until a certain concentration is reached, after which the fungus tends to be inhibited.

The effect of superphosphate at Walpeup was not as great as in 1932, but there appears to be a trend in the different experiments indicating that this fertilizer does tend to cause some reduction in infection.

It is interesting to note that high infections have been obtained on soils with pH values ranging from 5·5 to 8·7.

Resistance to Infection as Influenced by Chemical Factors.

From the above results, it is evident that an alteration in the soil solution, due to the application of manurial dressings, causes a change in the degree of infection produced when uniformly infected seed is sown. The changes observed have not been consistent, and they vary apparently with both season and soil type or condition. It is possible that the varying degree of resistance exhibited is due to changes in the vitality of the plants as a result of the additional plant food provided or released by the fertilizer treatment. These variations may be caused, however, by some single chemical factor responsible for the resistance of wheat to Flag Smut infection, although no such factor has been discovered so far. It was hoped that by inducing fluctuations in the chemical composition of the plant by the application of various fertilizers, the changes so produced could be correlated with variations in the plant's resistance to the disease.

The application of fertilizers to wheat produces changes in both the morphology and physiology of the plant, various aspects of which have been studied by different workers.

The effect of fertilizers upon the composition of the wheat plant was investigated by Richardson (54) at the State Experiment Farm, Rutherglen. He found that the phosphoric acid content of the straw appeared to vary with the relative proportions of potash, lime, and nitrogen applied. Heavy dressings of nitrogen produced marked increases in nitrogen and potash, and a decrease in the phosphoric acid content of the straw. Heavy applications of phosphoric acid produced a fairly substantial increase in the phosphoric acid content of the straw, provided the soil was deficient in either nitrogen, potash, or lime. In soils well supplied with these substances, a dressing of phosphoric acid lowered the phosphate content of the straw. Richardson further found that excess of lime does not materially affect the nitrogen and potash content of the plant, but slightly depresses the phosphate content of the straw and roots.

In addition to an effect upon the composition of the plant, it has been shown by Hurst (29) that the morphological structure of the stem can be changed by the use of fertilizers. The differences in infection of wheat with *Puccinia graminis* Pers. caused by fertilizers is attributed by Hurst to changes produced in the morphological structure of the plant.

Hart (25) has suggested that fertilizers exercise a direct effect upon the physiologic reaction of the plant to rust. This is in accord with the results of Draghetti (15), which support the view that resistance to rust (*Puccinia graminis*) in wheat is largely determined by the edaphic-physiological conditions of the host, and the osmotic activity of the cellular fluids; such osmotic activity being dependent upon the degree of concentration of the osmotically active nutrient and non-nutrient cellular salts. Under natural conditions *Triticum durum* and *T. turgidum*, which have the highest osmotic pressures, are immune. As mentioned previously, *T. durum* is also very highly resistant to Flag Smut. Draghetti states further that nitrogenous soil dressings conduce to rust by the alteration they effect in the osmotic properties of the cells, and it is concluded that osmotically active non-nutrient salts regulate the plant's absorption of water and serve as an osmotic defence against fungal attack.

These results are interesting, as it has been shown that osmotic pressure has an influence on other properties of the plant. Experiments

conducted by Berkner and Schlimm (4) indicate that yield, earliness, and drought resistance increase, but transpiration coefficients decrease, with increase of osmotic pressure. In addition, Buchinger (9) found evidence that within a number of wheat varieties studied, those plants with the lowest osmotic pressure displayed the highest degree of sterility.

It was considered possible that this theory of resistance of wheat to fungal disease could apply in relation to Flag Smut infection, but it was found impracticable to study more than the changes in the chemical composition and resistance of the plant induced by the application of various fertilizers.

The experiments were conducted at Rutherglen and Walpeup in 1933 concurrently with those already described. It was not possible to obtain analyses for all the treatments included in the experiment, so that plants from the following treatments only were analyzed:—No Manure, Superphosphate, Lime, Ammonium sulphate, and Sulphuric acid. Representative samples were taken at six and nine weeks after germination, each sample being analysed by the Agricultural Research Chemist for ash, nitrogen, phosphoric acid, potash, and lime contents. The roots were not included in the determinations. One hundred plants were taken from each treatment at the first sampling, and 40 at the second.

It has been shown by Knowles and Watkin (33) that large variations in the composition of the plant take place during growth. The composition of the plant in the early stages may have a greater influence on the disease than later, and for this reason two analyses were made at different times. Experience has shown that the first appearance of the disease under field conditions is generally from ten to twelve weeks after germination, so that the second analysis was taken just prior to the expected appearance of the disease. Actually the disease was first recorded at both centres approximately eleven weeks after germination.

TABLE VII.—RESULTS OF ANALYSES, AS PERCENTAGE ON DRY BASIS, OF PLANTS FROM FLAG SMUT MANURIAL TESTS AT RUTHERGLEN AND WALPEUP.

Treatment.	Rutherglen.					Walpeup.				
	No Manure.	Super-phosphate.	Lime.	Sulphate of Ammonia.	Sulphuric Acid.	No Manure.	Super-phosphate.	Lime.	Sulphate of Ammonia.	Sulphuric Acid.
(a) First Sampling—Six Weeks after Germination.										
Nitrogen	4·40	5·51	4·55	4·34	5·22	5·00	5·32	5·05	5·46	4·95
Total Ash ..	13·72	16·96	14·24	13·67	16·02	22·86	22·99	21·90	20·45	20·89
Silica (SiO_2) ..	4·81	5·21	4·73	5·58	6·03	10·85	9·79	9·61	7·98	8·73
Silica-free Ash ..	8·91	11·75	9·51	8·09	9·99	12·01	13·20	12·29	12·47	12·16
Lime (CaO) ..	0·50	0·54	0·56	0·45	0·55	0·73	0·77	0·73	0·80	0·75
Potash (K_2O) ..	4·31	6·01	4·67	3·83	4·98	5·34	5·91	5·67	5·49	5·56
Phosphoric Acid (P_2O_5)	0·71	1·47	0·68	0·60	0·88	1·12	1·56	1·22	1·14	1·09
(b) Second Sampling—Nine Weeks after Germination.										
Nitrogen	4·36	4·47	4·36	4·97	3·99	4·78	5·44	5·11	4·88	4·73
Total Ash ..	17·64	23·14	22·84	19·00	27·92	19·52	18·86	16·13	17·46	17·31
Silica (SiO_2) ..	8·93	13·40	13·91	9·44	19·68	8·53	6·61	4·78	6·13	6·23
Silica-free Ash ..	8·71	9·74	8·93	9·56	8·24	10·99	12·25	11·35	11·33	11·08
Lime (CaO) ..	0·42	0·35	0·42	0·29	0·28	0·56	0·51	0·59	0·68	0·58
Potash (K_2O) ..	4·24	4·99	4·33	4·94	4·09	4·91	5·79	5·29	5·27	5·20
Phosphoric Acid (P_2O_5)	0·77	0·99	0·85	0·93	0·75	0·85	1·31	0·88	0·80	0·86
Infection: Per cent.	83·4	62·4	81·6	73·6	33·2	72·9	72·3	65·5	43·9	70·5
Infection: Standard Error	5·3%					2·3%				

From Table VII., which gives the results of the chemical analyses of plants, it is seen that variations in the percentage of the different constituents, on a dry basis, occurred at the two samplings.

In addition to these analyses, it was considered desirable to obtain information as to the effect of infection alone upon the composition of the plant. At Walpeup there were plots sown on an adjacent area under identical conditions with infected and non-infected seed of Free Gallipoli, to which no manure had been applied. Two samples of plants were therefore obtained from these plots, one consisting of infected plants in which sori had been produced, and the other of plants which were apparently quite healthy. The plants at the time of sampling were about twelve weeks old.

As shown in Table VIII., these plants were analyzed for the same constituents as in the previous analyses.

TABLE VIII.—RESULTS OF ANALYSIS, AS PERCENTAGE ON DRY BASIS, OF PLANTS OF FREE GALLIPOLI INFECTED AND NON-INFECTED WITH UROCYSTIS TRITICI.

—	Non-infected.	Infected.
	Per cent.	Per cent.
Nitrogen	3·48	3·44
Total Ash	12·85	12·50
Silica (SiO_2)	4·50	4·64
Silica-free Ash	8·35	7·86
Lime (CaO)	0·38	0·36
Potash (K_2O)	4·17	3·97
Phosphoric Acid (P_2O_5) ..	0·53	0·49

It was thought that these analyses would show whether the infected plant was definitely poor in any particular constituent, and thus serve as a guide in interpreting the changes in infection and chemical composition occurring in the manurial rows. The infected plants were found to be poorer in all constituents except silica, as compared with the non-infected plants. The greatest decreases occurred in phosphoric acid and silica free ash, while total ash and nitrogen showed very little change. It was evident that infection with Flag Smut had an influence upon the chemical composition of these plants; but it seemed that the most important feature was a general reduction in all constituents, rather than an effect upon any particular one.

Scatter diagrams have demonstrated that no apparent relation exists between Flag Smut infection and changes in any single constituent included in the analyses. The significant differences in infection obtained from superphosphate and sulphuric acid at Rutherglen, and ammonium sulphate and lime at Walpeup, cannot therefore be attributed to this cause.

A common feature in the analyses of the plants from these treatments was the increase in the percentages of all constituents as compared with no manure at the first sampling. This change is interesting, as it has been shown that infection alone causes or is accompanied by a general reduction in these constituents. It is possible, therefore, that the development of the fungus within the host may be inhibited by a general increase in the percentages of nitrogen, ash, lime, potash, and phosphoric acid in the host plant during the early stages of its growth.

A further study of the growth relations of host and pathogen is desirable, however, to determine how far the responses to different manurial treatments may be due to other factors in addition to variations in the chemical composition of the plant. The rate of growth of the host has an important influence upon the disease, and the response to ammonium sulphate at Walpeup was probably due in part to the increased growth of the wheat plant promoted by this fertilizer.

5.—The Effect of Flag Smut on Yield of Wheat.

It has been recognized for some time that there is a difference in the reaction of various wheat varieties to Flag Smut. Experiments have shown that in general susceptible varieties, such as Indian H. and Federation, tend to produce a greater percentage of totally infected plants than do the more resistant varieties, as for example Geeralying, Cedar, and Nabawa, in which more partial infections occur.

Jarrett (30) and others have shown that microscopic examination may reveal the presence of the fungus in the base of the plants of resistant varieties, even though the plant appears to be quite healthy. This "suppressed" type of infection is missed in ordinary infection counts, but it seems probable that it has an effect on the plant which can be estimated only by an investigation of yield.

Although there is little information as to the manner in which the Flag Smut organism affects the yield of wheat, it would appear from the foregoing that losses in yield may occur as a result of three types of infection as follow:—

1. Due to total infection, no grain being produced.

2. Due to partial infection. In this case one to several heads containing grain may be produced by the plant.
3. Due to the infection of plants which do not develop typical symptoms of the disease, i.e., "suppressed" infection.

A similar condition has been established in the parasitism of wheat by *Tilletia tritici* (Bjerk) Wint., and its influence on yield investigated. It has been shown by Rodenhiser (56) that wheat varieties differ in their reaction to bunt infection. Further, Bolley (7) found that smutted heads are an indication of greater damage only. In a crop produced from smutted seed, in which 25 to 30 per cent. of the plants produced smut balls, he found it was difficult to obtain a plant in which the fungus could not be traced.

From observational evidence, Sutton (62) argued that considerable reductions in yield would occur, due to the effects of this type of bunt infection of plants which did not manifest typical symptoms of the disease. Sampson and Davies (57) obtained indications that the fungus *Tilletia tritici* had an adverse effect on the plant over and above that obviously shown by the replacement of healthy grain by bunted grain. Flor and others (19) further investigated the effect of bunt on the yield of wheat. They used three varieties of winter wheat, each differing in its susceptibility to the disease.

Although discrepancies occurred, the results indicated that the ratio of reduction in yield to percentage of smut was greatest in the resistant variety. This increased reduction in yield, as compared with the susceptible varieties, was apparently due to detrimental effects of bunt infection on plants which did not show the external symptoms of the disease.

Details of Experiment.

The object of the experiment was to determine how the losses in yield caused by *Urocystis tritici* are related to the percentage of infected plants in resistant and susceptible varieties, and to investigate by this means whether "suppressed" infection could influence the yield of wheat.

The test was conducted during 1933 on a uniform site at the Mallee Research Station, Walpeup. The soil was typical of large areas in the Mallee, being a greyish sandy loam containing a fair proportion of limestone. Determinations for pH on soil samples taken from the area ranged from 8.5 to 8.7.

Four varieties varying in their susceptibility to the disease were chosen, namely Federation, Free Gallipoli, Ghurka, and Nabawa. Federation and Free Gallipoli are both very susceptible, while Ghurka and Nabawa are resistant. Both inoculated and non-inoculated seed of each variety was used, the inoculated seed being heavily smutted with a mixture of spore material obtained from various parts of Victoria. Each treatment was replicated five times, making a total of 40 plots, each 1/30th acre, which were sown with a drill in randomized blocks, the rate of seeding being 45 lb. per acre. In an endeavour to obtain as high an infection as possible no fertilizer was sown, as previous experience at Walpeup had shown that superphosphate tended to reduce the percentage infection.

The plots were sown on 11th May, 1933, under favorable conditions for Flag Smut infection, the soil being extremely dry owing to a prolonged dry spell at the beginning of the year. The break in the weather occurred three days after sowing the plots, when 50 points of rain fell, thus assuring a good germination. The rainfall for the rest of the year was somewhat light, but timely falls resulted in very fair growth, although the plants were backward in the early stages. The monthly rainfall in points received to the end of November is as follows:—

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
133	0	15	11	170	29	148	138	154	104	109

Total for eleven months—1,011 points.

Typical symptoms of the disease were first recorded in the inoculated Federation and Free Gallipoli plots on 20th July, and in Ghurka and Nabawa approximately four weeks later. Before the appearance of these symptoms, however, it was possible to distinguish between the inoculated and non-inoculated plots, particularly of the varieties Federation and Free Gallipoli, as the inoculated plots developed a yellowish-green colour in comparison with the normal green colour of the untreated plots. This difference in colour became more marked after the appearance of the sori. Infection became very severe in the susceptible varieties, as indicated by a comparison of Figs. 10 and 11.

A measurement of the degree of infection was obtained for each plot before harvest by taking 28 2-ft. samples at random intervals along the length of the plot, two samples being obtained from each row. This procedure was based on Engledow's method (16), and gave approximately 350 plants per plot. In the case of the inoculated

Fig. 10.—Portion of a non-inoculated plot of Free Gallipoli in Yield Trial, Flag Smut Investigations, Walpeup, 1933.

Fig. 11.—View of one of the plots of Free Gallipoli inoculated with Flag Smut—Yield Trial, Flag Smut Investigations, Walpeup, 1933.

Federation and Free Gallipoli, in which the infection was very severe, a random sample of approximately 200 to 250 plants was obtained from which the infection was estimated. In all cases a distinction was made between total and partial infection.

From the appearance of the plots before harvest, as shown in Fig. 12, it was realized that large variations in yield would occur. The plots were harvested on 23rd November with a stripper and winnower. In calculating the yield per acre, allowance was made for the area occupied by the samples which were removed in estimating the infection.

Results.

Every precaution was taken to prevent external factors from affecting the results. For an accurate estimation of the effect of the fungus on yield, it is desirable that the non-inoculated plot be entirely free from smut. However a certain amount of soil infection was present, which, although small in comparison with the inoculated plots, would slightly affect the results. An attempt was made to decrease this error by estimating a yield for a smut free plot as shown later.

The average results obtained for each treatment for both yield and infection are shown in Table IX. From this table it will be seen that large differences in both yields and infection occurred between the different treatments of the two susceptible varieties, the variation not being so great for Ghurka and Nabawa.

Table IX.—Results of Yield Trial, Walpeup, 1933, Showing the Average Figures Obtained for Each Treatment for Yield and Infection.

Treatment.	Yield.	Infection.
	Bushels per acre.	Per cent.
Nabawa—Non-inoculated ..	14·9	0·2
Nabawa—Inoculated ..	14·7	1·9
Ghurka—Non-inoculated ..	20·4	1·0
Ghurka—Inoculated	17·7	8·3
Free Gallipoli—Non-inoculated	17·5	15·2
Free Gallipoli—Inoculated ..	5·2	79·3
Federation—Non-inoculated ..	13·9	14·9
Federation—Inoculated ..	4·4	79·2

Fig. 12.—View of inoculated plots in Yield Trial Walpeup, 1933, showing the small number of heads produced by Federation (right), as compared with Ghurka (left).

The experiment was interpreted in accordance with the method of analysis developed by Fisher and Wishart (18), the results being analysed as follows :—

- Total Variation.
  - Between treatments.
    - Due to variety.
    - Due to infection.
    - Due to interaction between variety and infection.
  - Within treatments.
    - Due to soil gradients (block variation).
    - Due to random plot variation.

This procedure was adopted for both yields and infections, as shown in Table X. From this analysis it is evident that the differences in yield

Fig. 13.—Portion of a non-inoculated plot of Free Gallipoli in Yield Trial, Walpeup, 1933, just prior to harvest.

Fig. 14.—Portion of an inoculated plot of Free Gallipoli in Yield Trial, Walpeup, 1933, just prior to harvest. Note the very reduced number of heads produced as compared with Fig. 13.

due to both variety and infection are significant. In a similar manner significant differences in infection have occurred. The significant interaction occurring in the analysis of variance for both yield and infection shows that the method of increasing infection used in this experiment has resulted in a differential effect between the varieties concerned.

TABLE X.—ANALYSIS OF VARIANCE FOR YIELD AND INFECTION OF RESULTS OF YIELD TRIAL, WALPEUP, 1933.

Analysis of Variance for Yield.

Due to—	Degrees of Freedom.	Sum of Squares.	Mean Square.	½ log.e.
Total variance ..	39	1,378·23	35·34	..
(*a*) Between treatments ..	7	1,184·85	169·26	..
1. Varieties ..	3	561·13	187·04	2·6155
2. Infections ..	1	383·78	383·78	2·9751
3. Interaction ..	3	239·94	79·98	2·1909
(*b*) Within treatments ..	32	193·38	6·04	..
1. Blocks ..	4	123·17	30·79	1·7136
2. Random plot	28	70·21	2·51	0·4601

Analysis of Variance for Infection.

Due to—	Degrees of Freedom.	Sum of Squares.	Mean Square.	½ log.e.
Total variance	39	41,017·57	1,051·73	..
(*a*) Between treatments	7	40,469·39	5,781·34	..
1. Varieties	3	19,703·10	6,567·70	3·2437
2. Infections	1	1,1809·14	11,809·14	3·5371
3. Interaction	3	8,957·15	2,985·71	2·8495
(*b*) Within treatments	32	548·18	17·13	..
1. Blocks ..	4	140·67	35·17	0·6288
2. Random plot ..	28	407·51	14·55	0·1875

DISCUSSION.

(*a*) *Evidence of "Suppressed" Infection.*

From a consideration of the figures for the Ghurka variety in Table IX., it is evident that the difference in yield between the non-inoculated and inoculated plots (2.7 bushels per acre) is greater than can be accounted for by the difference between the percentage infection in these plots, particularly as it is shown in Table XI. that some of the infected plants were not totally infected, and would therefore produce some grain. The loss of yield cannot be attributed solely to the infection of plants which showed typical symptoms of the disease, and thus demonstrates the existence of decreased vitality in some or all of the remaining plants as a result of "suppressed" infection. The yield per plant in the inoculated plots may have been greater than that in the non-inoculated plots, due to a smaller number of effective plants per foot. If this were the case, the increased yield per plant was not sufficient to offset the reduction caused by "suppressed" infection.

(*b*) *Varietal Variation of "Suppressed" Infection.*

It appears that the reduction in yield due to Flag Smut in any one variety is proportional to the infection, at least with small ranges of infection. This has been demonstrated in bunt infection by Flor and others, the *amount* of infection varying with the variety. If Flag Smut were entirely absent in the non-inoculated plots the varietal constant for reduction in yield would be obtained from the following expression :—

$$\begin{pmatrix}\text{Varietal}\\ \text{constant}\end{pmatrix} K = \frac{X - Y'}{A'} \times \frac{I}{X}$$

where X = Yield of smut free plot.
Y' = Yield of inoculated plot.
A' = Percentage infection of inoculated plot.

In the above experiment, however, natural infection was unavoidable, so that the yield of the non-inoculated plot was less than X. In the case of Ghurka and Nabawa this infection was very small, so that the yield obtained for the non-inoculated plot would be very close to X.

On the assumption that within the range of infections produced in the above experiment, the reduction in yield of any particular variety is proportional to the infection, the yield of a smut free plot of any variety may be calculated from the expression—

$$X = \frac{A'Y - AY'}{A' - A}$$

where X = Yield of smut free plot.
Y = Yield of non-inoculated plot.
A = Infection of non-inoculated plot.

A numerical value (K) expressing the effect of infection on the yield of each variety is therefore obtained as follows :—

$$K = \frac{Y - Y'}{(A' - A)} \times \frac{I}{X}$$

The values of K obtained from this expression for each variety are shown in Table XI., and may be regarded as an estimate for the loss in yield in bushels per acre per 1 per cent. of Flag Smut infection for every bushel of yield of the variety concerned.

TABLE XI.—ANALYSIS OF THE EFFECT OF VARIETY ON THE REDUCTION IN YIELD CAUSED BY UROCYSTIS TRITICI.

Treatment.	Yield.	Infection.	Percentage of Infected Plants Totally Infected.	K.
	Bushels per acre.	Per cent.		
Ghurka—				
Non-inoculated	20·44	1·0	44·0	0·0179
Inoculated ..	17·72	8·3	66·3	
Nabawa—				
Non-inoculated	14·92	0·2	0·0	0·0094
Inoculated ..	14·68	1·9	21·6	
Free Gallipoli—				
Non-inoculated	17·52	15·2	69·5	0·0094
Inoculated ..	5·20	79·3	91·3	
Federation—				
Non-inoculated	13·92	14·9	91·6	0·0092
Inoculated ..	4·42	79·2	99·2	

On this basis of comparison it will be seen that the loss is practically the same for the susceptible varieties Federation and Free Gallipoli, and the resistant variety Nabawa. The greatest value of K was obtained for Ghurka, which is fairly resistant to the disease. The increased value of K for Ghurka over the other varieties—Federation, Free Gallipoli, and Nabawa—indicates that there was an effect upon the yield of Ghurka due to the infection of plants which did not develop typical symptoms of the disease. In contrast with the two susceptible varieties, the number of partially infected plants was considerably greater than whole infections in the case of Nabawa (Table XI.), which fact would, if anything, tend to reduce the loss in yield in this variety.

As the value of K for Nabawa is the same as for the susceptible varieties, it seems possible, therefore, that there was a greater effect upon yield due to this "suppressed" type of infection in this variety. Losses due to this type of infection in Federation and Free Gallipoli were probably very small, owing to the high infection obtained in these varieties, and to the large percentage of totally infected plants which were produced.

It would seem, therefore, that under the conditions of this experiment, losses due to this type of infection were more evident in the resistant varieties. Ghurka, while having the power to "suppress" infection, is apparently not sufficiently resistant to prevent the fungus affecting the yield of the plant. One might expect, therefore, that under favorable environmental conditions this "suppressed" infection might develop sufficiently to produce sori. Actually, this has been supported by practical evidence. It is known that Ghurka, which in the Susceptibility Trials, conducted by this Department, has been classed as "resistant," may develop a comparatively high degree of infection under certain conditions. In one instance at the State Research Farm, Werribee, an infection of approximately 40 per cent. was recorded in a Ghurka row. In another case, during the judging of a crop competition in the Northern Wimmera in 1932, a crop of Ghurka was inspected, in which approximately 50 per cent. of the plants showed symptoms of the disease. Under ordinary conditions Ghurka does not show much infection, but apparently environmental conditions in these cases were such that a large proportion of the infection appeared.

Similar variations in varietal response to environmental conditions have been recorded for bunt infection by Gaines and Smith (21), and Faris (17), so that it is not surprising that this experiment indicates that different wheat

varieties exhibit a similar variation in the effect of Flag Smut on yield as that recorded for bunt.

6.—*Cultural and Other Factors in Relation to the Disease.*

Various observations have been made concerning the relation to the disease of depth of sowing, cutting back, and seed treatment, and experiments were conducted to confirm these results under Victorian conditions.

(*a*) Depth of Sowing.

Shallow sowing has been generally advocated on badly infested areas as a method of decreasing the damage caused by *Urocystis tritici*. Observations by Shepherd (59) have indicated that deep sowing on such areas may lead to a very large increase in infection.

Depth of sowing trials were carried out at Walpeup and Longerenong in 1933. At each centre one set of rows was sown 2 inches deep, and the other was sown very shallowly, the seed being just covered. In the deeper sowing, the susceptible stage of the plant was prolonged by two to three days, owing to the greater length of the shoot before the plant appeared above ground; hence the risk of infection in these rows was increased. It is not surprising, therefore, that the results (Table XII.) revealed an appreciable increase in infection in the deeper sown rows.

Not only was the percentage infection increased by the deeper sowing, but the proportion of whole to partial infection was also greater. This fact supports previous statements regarding the relation between an increase in the risk of infection and the severity of the symptoms produced. These results indicate that shallow sowing is desirable on areas where the disease has been serious previously.

(*b*) Cutting Back.

The severity of infection in a variety may be increased by cutting back the plants and compelling them to produce new tillers. Griffiths (24) has shown that there is no uniform response for each variety at each stage of development when cut back, but that it is possible by this means to hasten the date of appearance of the disease. Noble (46) has stated that "No direct field observations as regards the expected increase in the amount of Flag Smut which should subsequently develop in a crop if the observations *re* cutting back are correct, have apparently been made."

These observations are important, as it has been the practice of some farmers under certain conditions to feed off their wheat crops in the early stages of development.

Information on the relation of "cutting back" to infection has been obtained from tests at Walpeup and Longerenong during 1932–3. In 1932, drill rows were sown with infected seed of six varieties. Two rows of each variety were sown, the plots being 1 chain long and three hoes wide. One plot of each variety was cut back level with the ground approximately six weeks after germination. Only a small amount of infection developed in these plots, but it was indicated that cutting back did result in a small increase in infection.

This was confirmed by further work at Walpeup and Longerenong during 1933, where hand rows

Table XII.—Results of Depth of Sowing Tests, 1933.

Treatment.	Walpeup.					Longerenong.				
	Infection.			Total Plants.	Per cent. Infection.	Infection.			Total Plants.	Per cent. Infection.
	Whole.	Partial.	Apparently Healthy.			Whole.	Partial.	Apparently Healthy.		
Free Gallipoli—										
Sown deep ..	33	74	132	239	44·8	7	99	283	389	27·3
Sown shallow ..	6	34	184	224	17·9	3	38	226	267	15·3
Indian H.—										
Sown deep ..	117	34	33	184	82·1	..	..	..	..	..
Sown shallow ..	41	24	141	206	31·6	..	..	..	..	..

TABLE XIII.—THE EFFECT OF CUTTING BACK ON FLAG SMUT INFECTION.

Variety.	Walpeup.		Longerenong.									
	Normal.	Cut-back.	Normal.					Cut-back.				
			Infection.			Total Plants.	Per cent.	Infection.			Total Plants.	Per cent.
	Per cent. Infection.	Per cent. Infection.	Whole.	Partial.	Apparently Healthy.			Whole.	Partial.	Apparently Healthy.		
Free Gallipoli ..	67·2	69·2	4	94	164	262	37·4	6	67	161	234	31·2
Ghurka ..	9·4	8·2	0	12	263	275	4·4	2	20	213	235	9·4
Federation ..	65·5	68·5	50	65	159	274	42·0	55	35	138	228	39·4
Ranee 4 H. ..	55·4	61·8	0	36	268	304	11·8	4	23	223	250	10·8
Indian H. ..	81·5	86·1	52	41	118	211	44·1	57	26	118	201	41·3
Currawa ..	29·7	40·4	0	17	249	266	6·4	1	13	203	217	6·5

were sown in preference to drill rows. The varieties tested together with infections obtained are shown in Table XIII.

These results have shown that the alteration in total infection resulting from cutting back was not very great. At Longerenong counts of whole and partial infections were made and, from the figures, it is apparent that, although the percentage infection was not affected to any appreciable extent, the proportion of wholly to partially infected plants was greater in those cut back.

Where Flag Smut infection is a major problem feeding off a crop is undesirable, therefore, as under such conditions the disease is liable to cause greater damage.

(c) SEED TREATMENT.

It has been shown that spores of Flag Smut carried on seed wheat can be destroyed by treating the seed with certain fungicides, but writers are agreed that his treatment is ineffective as a means of control where spores are present in the soil.

Good control of seed-borne infection was obtained by Tisdale and others (65) and Verwoerd (68) by dusting the seed with copper carbonate, but Morwood (41) obtained most satisfactory results by steeping the seed-grain in a 1 to 5 per cent. solution of copper sulphate for three minutes, or a 1 in 400 formalin solution for ten minutes. Later experiments (42) have shown that copper carbonate completely controlled light seed-borne infection, but was not entirely satisfactory for heavily infected seed.

Experiments were conducted during 1932–33 to determine the efficacy of copper carbonate against seed-borne Flag Smut infection. Seed was heavily inoculated with Flag Smut spore material, and then dusted with copper carbonate at the rate of 2 ozs. per bushel. The results of these tests are shown in Table XIV.

TABLE XIV.—RESULTS OF PICKLING TESTS, 1932–33, SHOWING THE AVERAGE PERCENTAGE OF FLAG SMUT INFECTION OBTAINED.

Treatment.	Walpeup.	Rutherglen.	Longerenong.
	Per cent. Infection.	Per cent. Infection.	Per cent. Infection.
Untreated ..	40·2	45·0	36·9
Copper carbonate ..	5·9	7·5	2·0

These results have shown that copper carbonate gives very considerable, though not complete, control in the case of heavy seed-borne infection. Seed as heavily infected as that used in these tests is not met with under ordinary conditions, so that dusting with copper carbonate or similar copper powders should adequately control the source of infection.

The practice of pickling seed, with dry copper powders, for the control of bunt is very widely used in Victoria, and it is satisfactory to know that this treatment is effective against seed-borne Flag Smut infection.

Control Measures.

In addition to the use of resistant varieties, principally Nabawa, certain cultural methods for the control of Flag Smut have been suggested

and practised, the object being to reduce the number of viable spores in the soil at the time of sowing (39). Although useful, these methods have not been wholly effective where regular cropping with susceptible varieties is practised. Under these conditions the effect of the disease may become cumulative, and heavy losses in yield are liable to occur. The longevity of the spores in the soil forms the principal problem in the control of the disease by cultural methods.

From a consideration of the nature of the disease, and from the results of experimental work, the following methods of control are suggested.

1. *Burning Infected Stubble.*

The parts of infected plants, breaking up and falling to the ground, constitute the main source of infection from year to year. An early and good stubble burn should destroy a great number of the spores before they gain protection in the ground.

2. *Fallowing.*

Being an obligate parasite, the fungus, after the germination of its spores, must find a suitable host plant. Any spores which germinate during the fallow period must necessarily die, and the practice of fallowing therefore reduces the risk of infection from Flag Smut. This risk is considerably greater in wheat sown on the stubble of an infected crop.

3. *Rotation of Crops.*

As *U. tritici* attacks the wheat plant only, the growing of other crops in rotation with wheat extends the period during which the spores may germinate in the absence of their host plant. Oats for hay, grain or grazing is a suitable crop for this purpose, but, in a district where wheat is the main crop, it is impossible to design a practical system of crop rotations to cover the whole of the viable period of the spores in the soil.

4. *Careful Pickling.*

Seed-borne Flag Smut infection may be controlled by thorough pickling as is the case with ball smut. In ordinary circumstances heavily infected seed is not met with, and satisfactory control is afforded by copper powders.

5. *Delayed or Wet Sowing.*

Observational and experimental evidence have shown that early sowing often results in more heavily infected crops than later sowings of the same variety. This is due to the fact that weather conditions during the early part of the season are usually more favorable for infection than they are towards the end of the sowing period. Cold weather and a wet-seed bed at sowing time are unfavorable to the germination of spores of *U. tritici.*

6. *Shallow Sowing.*

It has been shown that shallow sowing results in a decrease in infection as compared with deep sowing. Shallow seeding is therefore recommended when wheat is to be sown on areas previously known to be infected.

7. *Manurial Treatment.*

The use of superphosphate when sowing wheat is generally warranted by the increased yields obtained. In addition, on areas infected with Flag Smut, the use of this fertilizer tends to decrease the losses due to the fungus.

8. *The Use of Oaten Hay in Preference to Wheaten Hay.*

The spores of *U. tritici* may pass uninjured through the alimentary canal of animals fed on diseased wheaten hay or chaff. Flag Smut may be introduced to uninfected areas by this means, and therefore in the interest of disease control the use of oaten hay is to be preferred.

9. *Feeding Off the Crop.*

The severity of the disease is increased by feeding off the crop in its early stages, and this practice should be avoided where the disease is a serious problem.

10. *Resistant Varieties.*

The most efficient method of control of Flag Smut is the cultivation of wheat varieties which are resistant to the disease. Varieties, such as Ghurka, which are both prolific and resistant to Flag Smut, are most valuable for this purpose. Nabawa has proved to be more resistant than Ghurka, but the use of the latter variety is recommended, because of its greater prolificacy and suitability for general conditions in Victoria.

Two prolific new cross-breds, Rajah × Gallipoli, and Currawa × Indian E. × Telfords, promise to be of great value in the control of the disease.

Summary.

An account of the distribution, economic importance, and symptoms of the disease Flag Smut of wheat is given, together with a description and life history of the fungus *Urocystis tritici* Koern, which causes the disease.

Flag Smut investigations were conducted at the following centres during 1931–33:—Mallee Research Station, Walpeup; State Research

Farm, Werribee; State Experiment Farm, Rutherglen; Longerenong Agricultural College; Shepparton; Warracknabeal; and the Plant Research Laboratory, Burnley.

A description of the procedure and technique used is given. The most practicable method of infection for field trials is that of dusting the seed with spores of the fungus. Where the seed is sown soon after treatment, this method may be modified to that of moistening the grain with a fine spray of water prior to the application of the spore load. Trials on infected land with clean seed proved unsatisfactory for accurate varietal susceptibility trials.

High infections are necessary to compare accurately the susceptibilities of varieties. It was found that the amount of smut which developed in any particular varietal susceptibility trial had an appreciable effect upon the results obtained. Where low infection occurred, many of the more resistant varieties exhibited an apparent resistance which was much greater than the inherent resistance of those varieties.

During 1931–33 trials were conducted at several centres under different soil and climatic conditions. The common wheat varieties, and the more promising cross-breds grown in Victoria, were tested, and their reactions to *U. tritici* have been determined. Most of the popular wheats are susceptible to the disease, but a number of varieties are resistant, or moderately resistant.

The investigations have shown that the use of resistant, or moderately resistant, varieties provides a valuable means for the control of Flag Smut, and their continued use should serve to reduce the losses on affected areas. The discovery that the Ghurka variety is resistant to the disease is particularly valuable, as it has been proved a prolific wheat under general conditions in many districts.

In susceptible varieties, the number of totally infected plants generally exceeds those partially infected, but the reverse is found usually in resistant varieties. So far attempts to obtain resistant strains by selection have been unsuccessful.

The absence of excessive moisture, together with the occurrence of temperatures above 50° Fahrenheit, constitute favorable conditions for the germination of the spores of *U. tritici* and subsequent infection of the plant. The disease is favoured by conditions which increase the duration of the susceptible stage of the host plant.

Flag Smut infection was influenced by certain manurial treatments at Rutherglen and Walpeup. Superphosphate generally caused a decrease in infection, but the effects of lime and sulphate of ammonia varied.

Severe Flag Smut infections have been obtained on various soils showing a wide range of pH values.

The development of the fungus is influenced apparently by a general increase in the percentages of nitrogen, ash, lime, potash, and phosphoric acid in the host plant during the early stages of its growth. No relation was demonstrable between Flag Smut infection and any single constituent.

Replicated trials with inoculated and non-inoculated seed indicated the extent to which yields may be reduced by Flag Smut.

"Suppressed" infection has been shown to occur in the parasitism of wheat by *U. tritici*. This type of infection caused a reduction in the yield of the Ghurka variety in addition to that resulting from visible infection. In the Nabawa variety the effect of "suppressed" infection was not evident.

Deep sowing led to an increase in infection as compared with shallow sowing.

The losses resulting from Flag Smut were increased slightly by cutting back infected plants.

Seed treatment with copper powders does not give complete control in the case of heavy seed-borne infection, but affords satisfactory protection under ordinary conditions.

Various measures for the control of the disease are recommended.

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Poultry Disease Control

(Continued from page 409).

whether they were hatched from eggs introduced from other farms, or were in contact with chickens hatched from foreign eggs.

If a fatal disease amongst chickens appears within a few days, or even a week or two after hatching, and no faults can be found in the system of incubation or general management, Pullorum disease may be suspected. This disease is carried through the egg state, and there is no other method of prevention than to breed only from healthy fowls. Birds which survive an attack will lay infected eggs, and thus perpetuate the disease. Fortunately, affected birds can be discovered by means of the agglutination test, and the disease may be eliminated from an infected stock by the regular application of this test, and removal of reactors.

If deaths occur at a later stage, the cause will probably be coccidiosis, which may be prevented by placing the chickens on a wire-netting floor in the brooder, and by strict hygienic measures.

All these details should be noted and supplied to the investigator for his assistance. If an outbreak occurs on a farm, sales and deliveries should be held up pending an accurate diagnosis. The sale of birds affected with a contagious disease is to be deplored, not only because it is an offence against the State laws, but because it is dishonest, and may inflict a very grave financial loss on the purchaser.

There is one other side to the question. No one should call himself a poultry-farmer unless he can recognize the symptoms of the more common diseases. In many cases, in spite of all that has been published in the press, and all the lectures given over the air, and to meetings of poultry-farmers, great losses occur from diseases which could have been checked in their early stages had the farmer recognized the symptoms and taken the steps necessary for control of the disease. In a book on the poultry industry issued by the Department of Agriculture (price 2s. 9d. posted), the symptoms of all the common ailments are fully dealt with.

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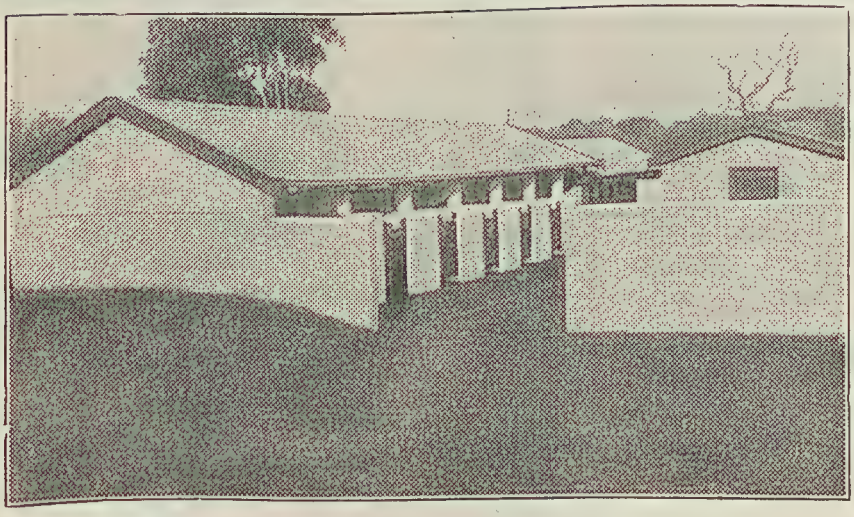

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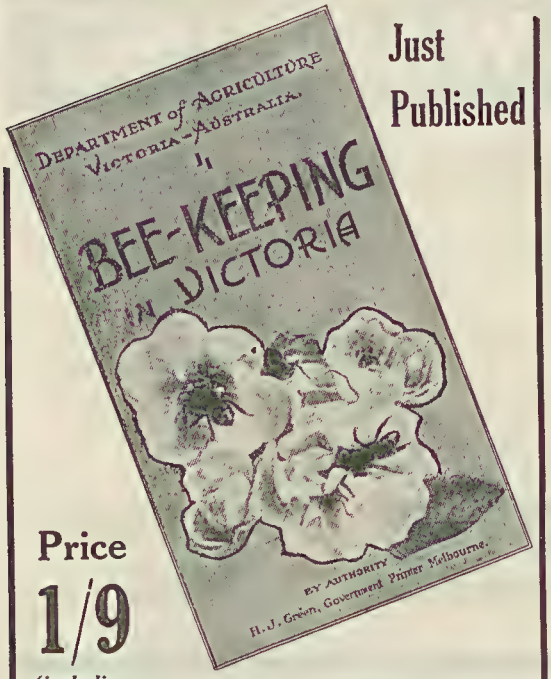

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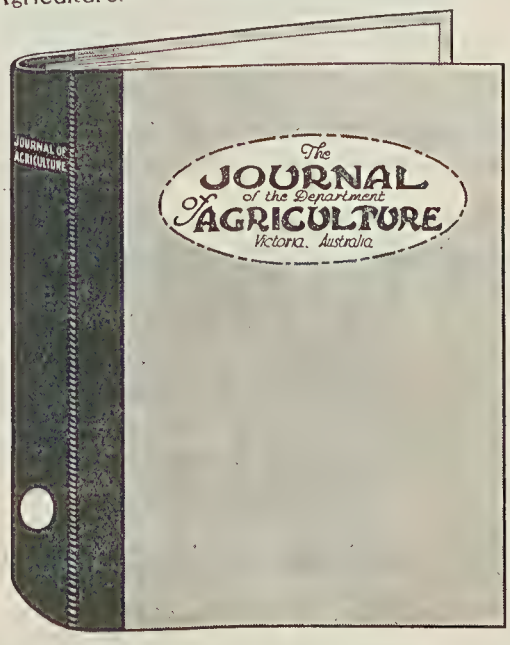

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SENIOR 4-YEAR-OLD			
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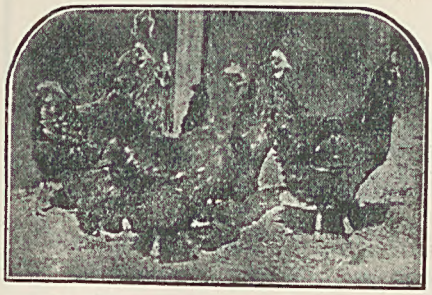

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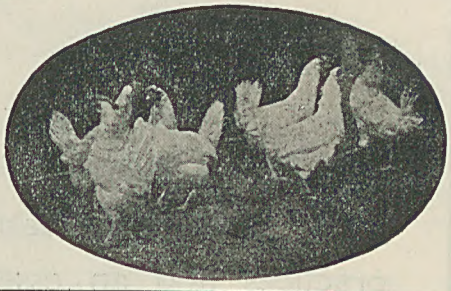

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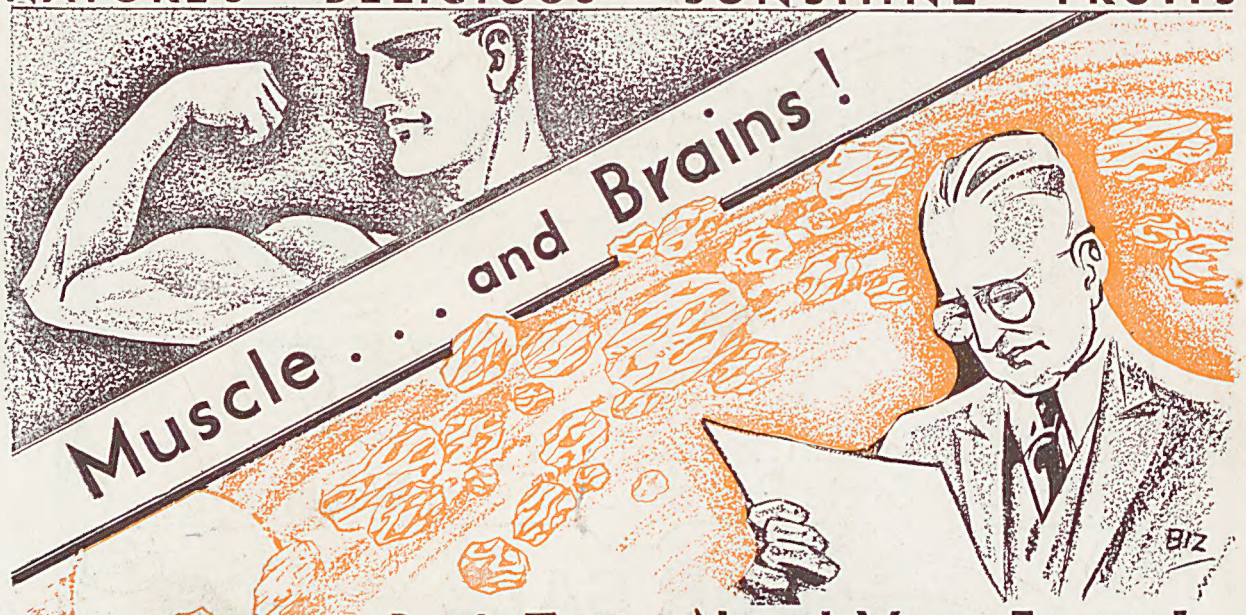

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